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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
999 18th STREET - SUITE 500
DENVER, COLORADO 80202-2466

329767

FILE PLAN
4.02

MAR 23 1998

Ref: 8HWM-SR

ADMINISTRATIVE RECORD

MEMORANDUM

SUBJECT: Explanation of Significant Differences (ESD)
Operable Unit 2 (OU 2)
Broderick Wood Products Superfund Site

FROM: Armando Saenz, Remedial Project Manager
Broderick Wood Project

TO: Robert L. Duprey, Director
Hazardous Waste Management Division

Attached is the ESD between the March 1992 OU 2 Record of Decision (ROD) and the remedy that will be implemented at the Broderick Site.

Since issuance of the OU 2 ROD, EPA has collected additional information through site studies and construction. Based on this new information, EPA and CDPHE determined that some changes are necessary in the ground-water remedy. The major differences are:

- Remediation goals will be met at points of compliance, which will be established.

New remediation goals will be set for the contaminated ground water in the shallow aquifer in the area within the points of compliance.

- A soil/bentonite cutoff wall will be constructed at the north boundary of the Broderick Wood Products property.

- Natural attenuation and biodegradation will be used to address the contamination in the dissolved plume to the north of the property.

The State of Colorado supports implementation of the remedy as described in this ESD. Also, EPA headquarters has been consulted on and concurs with this ESD. I recommend approval of the changes to the remedy described in this ESD.

Attachment

03/20/95 11:08 FAX 3037595355 CDPHE HAZMAT

BKD ouc

STATE OF COLC

329768

COLORADO DEPARTMENT OF HEALTH
Dedicated to protecting and improving the health and environment of the people of Colorado

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Roy Romer
Governor

Patricia A. Nolan, MD, MPH
Executive Director

March 24, 1994

ADMINISTRATIVE RECORD

Mr. Robert Duprey, Director
Waste Management Division
U.S. Environmental Protection Agency
999 Eighteenth Street, Suite 500
Denver, Colorado 80202-2405

Fax to Armando
295
1238

FILE PLAN
4.02

RE: Surficial Ground Water Remedy
Broderick Wood Products Superfund Site

Dear Mr. Duprey:

The Hazardous Materials and Waste Management Division of the Colorado Department of Health (CDH) concurs with the proposed Record of Decision (ROD) modification with respect to the surficial ground water remedy at the Broderick Wood Products Superfund Site located at 5800 Galapago Street in unincorporated Adams County.

This concurrence is based on the previous site data, new site information gathered during the Additional Site Characterization and the treatability studies, and discussions with the Robert S. Kerr Environmental Research Laboratories. The modification encompasses the following elements:

- Where present, free phase product* will be recovered from the surficial aquifer in the impoundment and process area.
- In-situ bioremediation (specifically bioventing) will be implemented at the completion of free phase product* removal, for the purpose of efficiently remediating the source areas.
- The North Boundary Cutoff System (drainline and slurry wall) will serve to maintain a hydraulic barrier to off-site contaminant migration via the surficial aquifer, and to pump and treat the dissolved phase present within the on-site surficial aquifer.

* free phase product means the Light Non-Aqueous Phase Liquid floating on the surficial aquifer

Mr. Robert Duprey
Broderick Wood Products
March 24, 1994
page 2/2

CDH believes this proposed ROD modification will meet the requirements of both CERCLA and RCRA. Please contact Howard Roitman at 692-3397, if additional issues remain.

Sincerely,

David C. Shelton, Director
Hazardous Materials and Waste Management Division

CC: Richard Sisk/EPA
Armando Saenz/EPA
Howard Roitman/CDH
Dan Scheppers/CDH
Rob Eber/AGO
Austin Buckingham/CDH

EXPLANATION OF SIGNIFICANT DIFFERENCES
RECORD OF DECISION (ROD) - OU 2
BRODERICK WOOD PRODUCTS SUPERFUND SITE

DECLARATION

Considering the new information that has been developed and the changes that have been made to the selected remedy chosen in the March 24, 1992 OU 2 ROD, EPA has determined that the remedy remains protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to this remedial action, and is cost-effective. In addition, the revised remedy utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable for this site.

Robert L. Duprey, Director
Hazardous Waste Management Division

3/6/95
Date

Explanation of Significant Differences for the Ground-Water Remedy

Broderick Wood Products Superfund Site

United States Environmental Protection Agency

February 1995

Broderick Wood Products Superfund Site
Explanation of Significant Differences
for the
Ground-Water Remedy
February 1995

Overview

The purpose of this document is to explain the significant differences between the ground-water remedy the U.S. Environmental Protection Agency (EPA) chose in the Record of Decision (ROD), signed on March 24, 1992, and the remedy that EPA is now planning to implement for the ground water at the Broderick Wood Products Superfund Site (Site) in unincorporated Adams County, Colorado. EPA is the lead agency at the Site; the State of Colorado Department of Public Health and Environment (CDPHE, formerly known as CDH) is the support agency.

This Explanation of Significant Differences (ESD) provides a brief history of the Site, describes the original ground-water remedy selected in the ROD (EPA, 1992), and explains the ways in which the proposed modified ground-water remedy differs from the original. It also summarizes the support agency's comments on the proposed changes to the remedy, discusses the proposed modified remedy's compliance with all legal requirements, and provides details on how more information can be obtained or comments can be submitted on the proposed modified ground-water remedy.

This ESD is prepared in fulfillment of EPA's public participation responsibilities under Section 117(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601 et seq. (CERCLA or Superfund), as amended by the

Public Participation Activities

This document presents only a summary of the changes to the ground-water remedy and a synopsis of information about the Site. The administrative record, which contains this ESD and the complete documentation supporting it, is available for public review at the following location:

EPA Superfund Records Center
999 18th Street
Denver, CO 80202
Hours: Monday through Friday 8:00 a.m. to 4:30 p.m.
Phone: 303/293-1807

EPA issued a Proposed ESD for the Ground-Water Remedy for the Site on September 15, 1994. A public comment period on the Proposed ESD was held from September 16, 1994 to October 15, 1994. Comments on the Proposed ESD were received from Burlington Northern Railroad (Appendix A). EPA reviewed the comments and prepared a responsiveness summary to the comments received (Appendix B). This ESD incorporates the adjustments to the proposed ESD that were made in response to the comments.

Site History and Background

The Site is located at 58th Avenue and Galapago Street in unincorporated Adams County, approximately 1/2-mile west of the intersection of Interstate Highway 25 and West 58th Avenue. The Broderick Wood Products Company (BWP) operated a wood treating facility at this location from 1947 to 1982 on a 64-acre triangular piece of property (BWP Property). The Site consists generally of the former BWP Property and an area north of the BWP Property contaminated by hazardous substances disposed on the BWP Property. As part of the wood treatment process, BWP used creosote and pentachlorophenol (PCP) to treat power poles, fence posts, railroad ties, and other wood products. Hazardous substances from the process were primarily disposed of in two unlined impoundments in the northwestern corner of the Site.

EPA became involved at the Site in 1980 when BWP applied for a permit under the Resource Conservation and Recovery Act (RCRA). EPA RCRA inspectors observed violations at that time. In 1982, wood treatment operations at the Site ceased. BWP's assets were transferred to a partnership called the Broderick Investment Company (BIC). In early 1983, sampling was conducted at the Site and PCP was detected in soil and ground-water samples. The BWP Site was placed on the National Priorities List (NPL) in September 1984. In 1985, a contractor hired by BIC to dismantle the wood treating plant started a fire that destroyed the process building and resulted in further contamination of the Site.

Remedial Investigation/Feasibility Study (RI/FS) activities were conducted in three phases: Phase I, completed in March 1984; Phase II, completed in December 1986; and Phase III, completed in June 1991.

After completion of the Phase II studies, EPA divided the remediation of the Site into two operable units (Ous). OU1 was established to deal principally with the sludges in the two surface impoundments at the Site. In a ROD signed in 1988, EPA chose an incineration remedy for OU1. As a result of changed circumstances and new information, the OU1 remedy was amended in 1992, and the impoundment sludges were sent off-site for reclamation. The OU1 remedy was completed in November 1992.

OU2 includes the remaining contaminated media at the Site, including ground water. The remedy for OU2 was chosen in the ROD signed in March 1992. In implementing the OU2 remedy, EPA has divided the work into two stages. OU2-Stage 1 involves remedial actions for the soil contamination, including construction and operation of a land treatment unit, decontamination and demolition of the buildings and structures, construction of a North Boundary Cutoff System (NBC)[1], and placement of a package water treatment plant to treat ground water captured by the NBC. OU2-Stage 1 work began in 1993 and was substantially completed in April 1994. Concurrent with performing the OU2-Stage 1 work, EPA conducted additional Site characterization and treatability studies. The preliminary results of these additional studies were reported in the January 1994 Draft Additional Studies Report (EPA, 1994a). OU2-Stage 2 involves construction and operation of the remainder of the ground-water remedy selected in the ROD (EPA, 1992).

Contamination Problems

The primary contaminants of concern at the Site include polynuclear aromatic hydrocarbons (PAHs), acid extractable compounds (primarily PCP and other chlorinated phenolic compounds), dioxins and furans, and some heavy metals (principally arsenic, cadmium, lead, and zinc).

Wood-treating chemicals (creosote, PAHs, and PCP) have been detected in the surficial and Denver aquifers.[2] The wood treating chemicals in the ground water are generally in the form of nonaqueous phase liquids (NAPL). NAPL is a term that refers to liquids that generally do not mix with water. NAPL can be either lighter (LNAPL) or denser

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[1]The NBC consists of a drain line placed at the top of the weathered Denver formation just south of Fisher Ditch on the north side of the BWP property. This system is designed to capture and contain contaminated surficial aquifer ground water on the BWP property.

[2]Three aquifers have been delineated below the Site:

- The surficial aquifer, which is made up of the alluvial deposits and the weathered Denver aquifer at depths down to approximately 25 feet below ground surface
- The unweathered Denver aquifer from approximately 25 to 180 feet below ground surface
- The Arapahoe aquifer at depths of greater than 180 feet below ground surface

the form of nonaqueous phase liquids (NAPL). NAPL is a term that refers to liquids that generally do not mix with water. NAPL can be either lighter (LNAPL) or denser (DNAPL) than water. The contamination in the ground water can be classified as one of three phases:

- Mobile (free) NAPL—NAPL is present in the subsurface and is able to flow into a well.

- Residual NAPL—NAPL is present on soil and looks oily, but will not immediately flow into a well.

- Dissolved NAPL constituents—NAPL constituents are dissolved in the ground water, but are not visible on soil or in the water.

On the BWP Property, Mobile LNAPL has been identified in the surficial aquifer in the impoundment area and in one small location in the process area. No Mobile LNAPL has been found beyond the BWP Property boundaries, and no Mobile DNAPL has been found within the surficial aquifer at the Site. Residual LNAPL and DNAPL have been identified in an area extending from the impoundment to the process areas and as far north as the north boundary of the BWP Property. No Mobile or Residual NAPL have been found off the BWP Property. A dissolved contaminant plume has been found extending from the impoundment and process areas north to a point about 1,000 feet north of the BWP Property. (See Figure 1 on Page 16.)

Summary of Ground-Water Remedy in the 1992 Record of Decision

The ground-water remedy in the 1992 ROD, termed ex-situ/in-situ bioremediation, includes the following major components:

- Collection of contaminated ground water and LNAPL from the surficial aquifer in a series of subsurface drain trenches located in the areas of highest ground-water contamination.

- Construction of a water treatment plant on the BWP Property. This treatment plant would be designed to first remove LNAPL and DNAPL from the collected ground water in an oil/water separator. Second, the plant would treat recovered ground water in a two-stage, fixed-film bioreactor. This second step is the ex-situ bioremediation.

- After treatment, a portion of the treated water would be mixed with nutrients and oxygenating chemicals, and reinjected into the surficial aquifer to stimulate bacterial growth and to promote further breakdown of contamination within the shallow aquifer. This is the in-situ bioremediation portion of the remedy.

- EPA determined that it was technically impracticable to actively remediate the Denver aquifer and waived Applicable or Relevant and Appropriate Requirements (ARARs) for that portion of the Denver aquifer under the BWP Property.

- Placement of institutional controls, such as deed restrictions or restrictive covenants, on future uses of ground water on the BWP Property by the current owner to control access to contaminated water in the surficial and Denver aquifers.

- Monitoring of ground water in all three aquifers for a period of 30 years on a periodic basis with approximately 10 to 15 wells on and off the BWP Property.

- Construction of at least one recovery well to the north of the BWP Property to contain the dissolved plume off of the BWP Property.

Description of Significant Differences

Summary of Significant Differences

The significant differences between the ground-water remedy described in the March 1992 ROD and this ESD are:

- Remediation levels in ground water will be attained at specified points of compliance instead of throughout the contaminant plume.

- New remediation goals will be established for the contaminated ground water within the points of compliance.

- A soil/bentonite cut-off wall will be constructed north of the NBC system and south of Fisher Ditch at the north boundary of the BWP Property.

- The recovery well off the BWP Property will be eliminated.

In addition, the following non-significant changes will be made to the ground-water remedy at the Site.

- The on-site water treatment plant that has been constructed as part of the OU2-Stage 1 NBC system will also be used to treat water produced from the drain lines. The treated water will be discharged to the Adams County stormwater system. Instead of a two-stage fixed film bioreactor, the treatment plant employs an activated clay and activated carbon treatment process.

- Oxygen will be introduced into the soils below the water table using the in-situ bioremediation process known as bio-venting instead of through re-injection of oxygenated water.

- The number of monitoring wells on and off the BWP Property will be increased from 10 to 15 to between 25 and 30.

All other aspects of the ground-water remedy, as set forth in the March 1992 ROD will remain the same. A more detailed description of the significant and non-significant changes to the ground-water remedy follows.

Basis for Significant Changes – New Information Since the 1992 ROD

Since issuance of the OU2 ROD in March 1992, additional information has become available. This information includes the data collected at the Site through additional site characterization activities, treatability studies, and information developed during implementation of the OU2-Stage 1 remedial action.

This information has helped EPA refine the Site conceptual model that was developed during the Phase III RI/FS. The new information indicates that:

- There are two primary contaminant sources, the impoundment area and the process area. In addition, significant dumping of debris and wood preserving wastes appears to have occurred over much of the Site, creating many minor sources that may contribute to ground-water contamination.

- These multiple contaminant sources on the BWP Property are contributing to one contaminant plume in the surficial aquifer.

- Residual NAPL contamination is present over a greater area of the BWP Property than previously anticipated.

- The soils in the surficial aquifer are more heterogeneous than indicated in the Phase III studies.

- The hydraulic conductivities of the surficial aquifer and the weathered Denver formation are relatively low.

- Of the ground-water technologies evaluated, none would be capable of reaching, within a reasonable period of time, the remediation levels set out in Table 13 of the March 1992 ROD.

- Computer modeling has shown that the dissolved plume to the north of the BWP Property is not moving and that natural biodegradation of the dissolved plume in the surficial aquifer will be as effective in meeting ARARs as a single, or several, recovery wells.

Significant Changes to Ground Water Remedy as a Result of New Information

The first significant change proposed by EPA as a result of the new information is to establish points of compliance beyond which the remediation levels established in Table 13 of the March 1992 ROD will be met. The NCP permits EPA to establish the appropriate locations for measurement of performance of the remedy, i.e., points of compliance. EPA's general policy is to attain remediation levels throughout the contaminated plume at or beyond the edge of the waste management area, when waste is left in place. However, this policy recognizes that in site-specific instances, alternative points of compliance may also be protective of human health and the environment.

Alternative points of compliance are appropriate at this Site for the following reasons:

- There are two primary and many minor sources of ground-water contamination on the BWP Property. In addition, the residual NAPL contaminant plume serves as a source of ground-water contamination on the BWP Property.

- These sources are in close geographical proximity and can effectively be addressed as a whole.

- The available information demonstrates that it is improbable that the areas of highest ground-water contamination can be restored to remediation levels in a reasonable period of time with any available technology.

- The likelihood of exposure to ground-water contamination on the BWP Property itself is low because title to the property is in a single owner, the property is in an industrialized area, and institutional controls that will restrict access to the contaminated ground-water can be implemented.

For these reasons, EPA is establishing the following points of compliance. (See Figure 2 on Page 17):

- Starting at a point in the northwest corner of the BWP Property approximately 10 feet east of the west boundary and 10 feet south of the north boundary, then east approximately 2,700 feet parallel to the northern property boundary of the BWP Property in the area north of the proposed soil/bentonite cutoff wall and south of Fisher ditch, then going southwest parallel to the southeast property line of the Broderick property approximately 2,000 feet to a point approximately 10 feet from the southwest property line of the BWP Property, then northwest parallel to the southwest property line of the BWP Property, back to the starting point. These lines are then extended vertically down through the surficial and Denver aquifers to the horizontal plane described below.

- Along a horizontal plane at the transitional marker bed between the Denver and Arapahoe formations. The transitional marker bed is approximately 180 feet below grade and is described in the Remedial Investigation Report as "the claystone/shale unit, typically 30 feet in thickness, but only about 15 feet below the BWP site" (BIC, 1990).

In adopting these points of compliance, EPA recognizes that the remediation goal established in the March 1992 ROD of restoring the surficial ground water under the BWP Property to a quality consistent with its potential future uses, may not be met within the points of compliance established above. As a result, EPA is establishing the following modified remediation goals for the contaminated ground water within the points of compliance:

- Control access to contaminated ground water within the points of compliance on the BWP Property to reduce or eliminate exposure.

- Reduce the mass of contamination within the points of compliance to reduce migration of contaminated ground water beyond the points of compliance.

- Contain contaminated ground water within the points of compliance.

The remediation goals that will be required for contaminated ground water beyond the points of compliance remain the same as stated in the March 1992 ROD. These included meeting the remediation levels for the surficial aquifer set out in Table 13 of the ROD.

EPA's strategy for meeting these remediation goals for ground water within the points of compliance is as follows: First, access to the contaminated ground-water within the points of compliance will be controlled by implementing institutional controls as set out in the March 1992 ROD. Deed restrictions or covenants will be established to prevent drilling or use of wells in the contaminated ground water within the points of compliance, with the exception of wells necessary for monitoring or remediation.

The second part of EPA's strategy to meet the remediation goals for the contaminated ground water within the points of compliance is to reduce the contaminant mass within the surficial aquifer. The treatability studies demonstrated that in-situ bioremediation, i.e., bio-venting, may produce substantial reduction of contaminant mass in the surficial ground-water. Reduction of contaminant mass will minimize the volume of contaminants moving vertically and horizontally to uncontaminated portions of the Denver and the Arapahoe aquifers. Use of this technology increases the overall protectiveness of the remedy by increasing the long-term effectiveness and permanence of the remedy and reducing the toxicity, mobility and volume of contaminants in the surficial aquifer. Additionally, the State of Colorado has stated that mass reduction is necessary for the remedy to comply with closure requirements under RCRA for the interim status surface impoundments. These closure requirements are ARARs for the Site. The bio-venting system will be operated until the reduction of contaminant concentrations levels off, as determined by EPA in consultation with the State.

Next, EPA is adding a soil/bentonite cut-off wall to contain contaminants in the surficial aquifer within the points of compliance. The cut-off wall is added for the following reasons:

- The cut-off wall will provide a positive cutoff and augment the NBC system in preventing the movement of contaminated ground-water horizontally in the surficial aquifer beyond the northern points of compliance and off the BWP Property.

- The cut-off wall will increase the efficiency of the NBC system.

- The cut-off wall will limit the flow of water that may seep from Fisher Ditch back to the NBC, thereby reducing the volume of water that will need treatment.

EPA's strategy for meeting remediation goals to the north of the BWP Property, beyond the points of compliance (as set forth in Table 13 of the March 1992 ROD), includes the following: First, the sources on the BWP Property as well as the contaminated ground water will be removed, controlled, or contained with the remedial action elements previously identified. Second, the computer modeling effort (refer to Technical Memorandum Attachment to the ESD) has shown that given the concentration of contaminants found to be present in the surficial aquifer, naturally occurring bacteria can aerobically degrade the contaminants in a reasonable time frame (estimated at 6 to 60 years). At the end of this period, ARARs (which have been established for the surficial aquifer) will be met. Finally, the effectiveness of biodegradation in the surficial aquifer off of the BWP Property will be monitored with a network of shallow ground-water wells installed at the limits of and within the dissolved plume as currently defined. The monitoring wells will provide data to document that the dissolved plume is not migrating and that biodegradation is reducing contaminant concentration.

Basis for and Description of the Non-Significant Changes to the Ground Water

Remedy

The following changes have been identified as non-significant.

- Rather than using a fixed film bioreactor process as the second component of the treatment plant, activated clay and activated carbon processes may be used.

  Carbon treatment systems have been used successfully at a large number of wood preserving sites across the nation. Given the ground-water flow rates and organic contaminant strengths found at this Site, activated carbon treatment systems are less costly than biological treatment systems and provide the same treatment effectiveness.

- The March 1992 ROD selected the injection of oxygenated water for the in-situ ground-water remedy. The new information indicates that bio-venting is proposed to be used as the most practical method of attaining mass reduction within the mobile NAPL plume at the BWP Property. The Additional Studies Report and Treatability Studies support the modification of the in-situ bioremediation technology. Specifically, the surficial aquifer was found to be heterogeneous and to have a limited capacity to accept injected water due to relatively low hydraulic conductivity. The heterogeneity combined with the low hydraulic conductivity serves to inhibit the uniform flow of oxygenated water throughout the aquifer. Soils are generally more permeable to air than water, and air contains a higher concentration of oxygen than water. To effect bioremediation in the subsurface and thus reduce the contaminant mass, oxygen must be supplied to the microorganisms to sustain their growth. Air injection (or bio-venting) has been shown (EPA, 1994a) as the most effective means of transmitting oxygen to the subsurface and circulating it throughout the subsurface.

CDPHE Comments

CDPHE concurs with the ESD and the changes to the ground-water remedy.

Affirmation of Statutory Determinations

Considering the new information that has been developed and the changes that are proposed to the selected remedy, EPA believes that the remedy remains protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to this remedial action, and is cost-effective. In addition, the revised remedy utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable for this site.

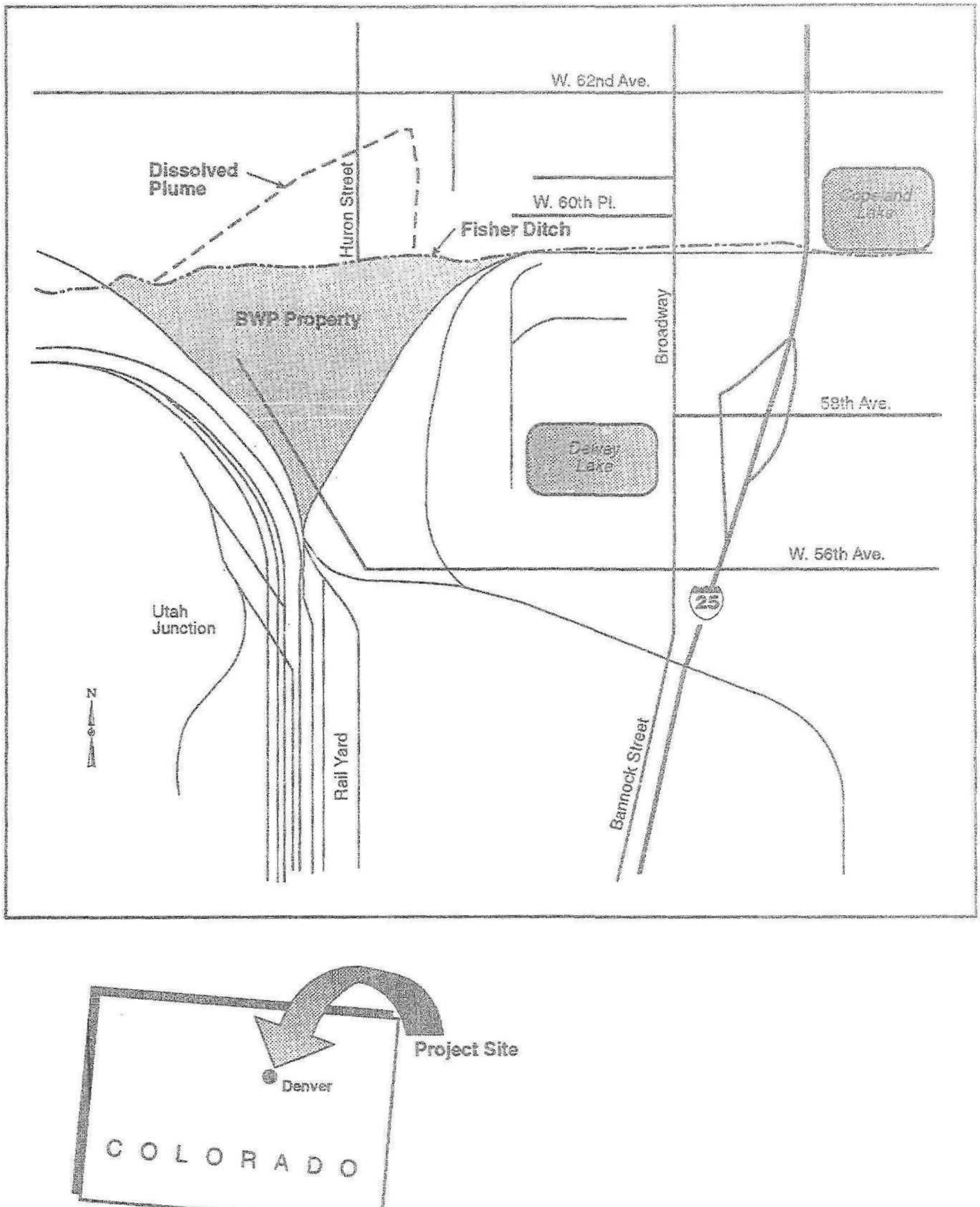
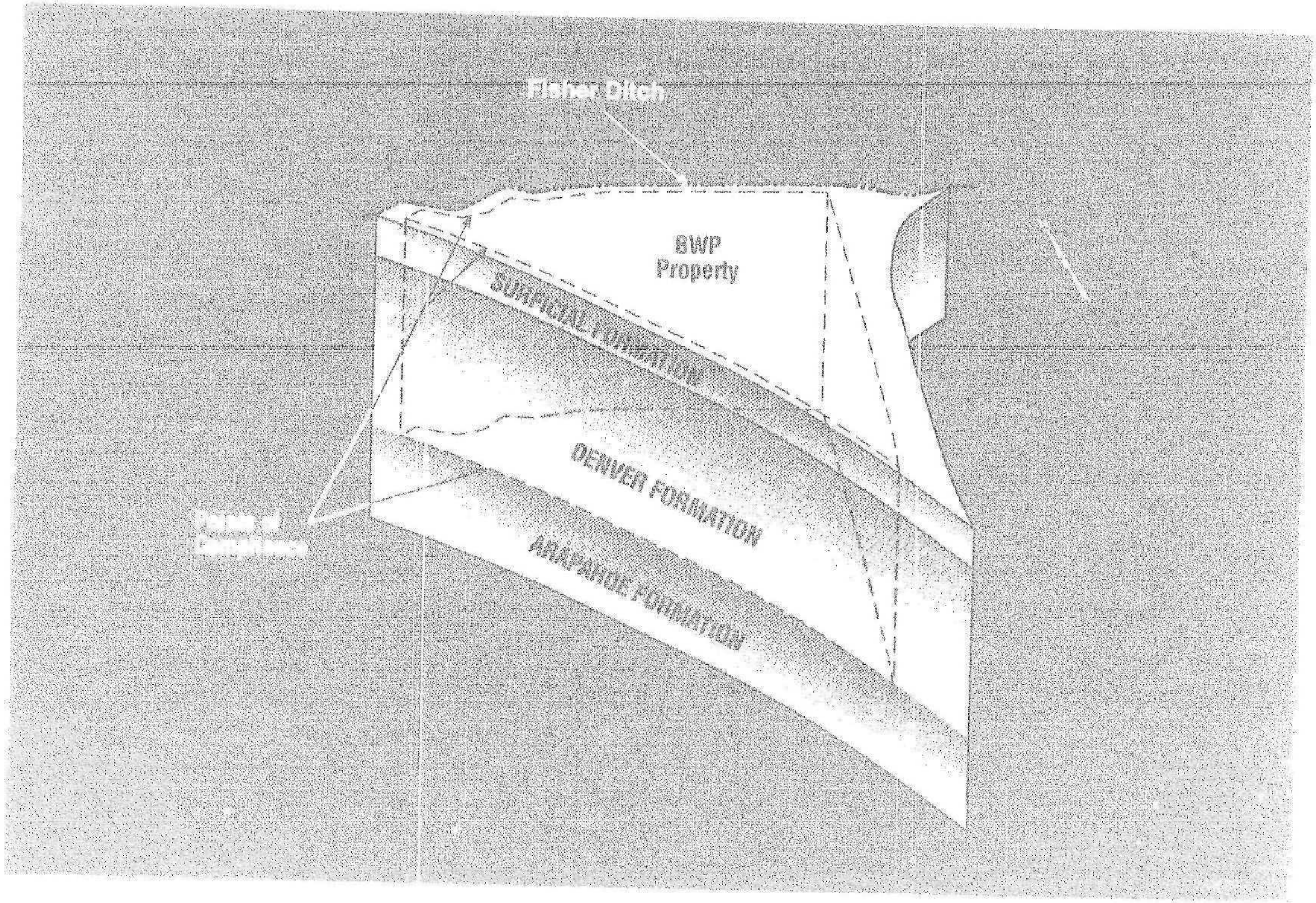


Figure 1
BWP PROPERTY SITE
VICINITY MAP


Fisher Ditch
BWP
Property
SURFICIAL FORMATION
DENVER FORMATION
ARAPAHOE FORMATION

References

Broderick Investment Company (BIC), 1990. *Phase III Remedial Investigation Report for Broderick Wood Products Site, Denver, Colorado.* December 20.

EPA, 1992. *Record of Decision Broderick Wood Products, Adams County, Colorado, Operable Unit 2—Final Site Remedy.* March.

EPA, 1994a. *Draft Additional Studies Report, Broderick Wood Products.* CH2M HILL. January.

EPA, 1994b. *Additional Studies Laboratory Data Technical Memorandum.* CH2M HILL. January.

EPA, 1994c. *Broderick Wood Products: Draft Preliminary Assessment of Off-site Contaminant Migration Technical Memorandum.* CH2M HILL. June 24.

List of Acronyms

ARARs	Applicable or Relevant and Appropriate Requirements
BIC	Broderick Investment Company
BN	Burlington Northern Railroad
BWP	Broderick Wood Products Company
CDPHE	Colorado Department of Public Health and the Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
DNAPL	Dense Non-Aqueous Phase Liquid
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Differences
FS	Feasibility Study
LNAPL	Light Non-Aqueous Phase Liquid
LTU	Land Treatment Unit
NAPL	Non-Aqueous Phase Liquid
NBC	North Boundary Cutoff System
NCP	National Contingency Plan
OU	Operable Unit
PAHs	Polynulear Aromatic Hydrocharbons
PCP	Pentachlorophenol
POC	Point-of-compliance
RA	Remedial Action
RI	Remedial Investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
Site	Broderick Wood Products Superfund Site
TM	Technical Memorandum

Technical Memorandum
Attachment to
Explanation of Significant Differences

Technical Memorandum
Attachment to
Explanation of Significant Differences

Introduction

This technical memorandum (TM) describes the development and application of numerical groundwater flow and particle tracking models to contaminant migration off of the Broderick Wood Products (BWP) property. Discussion is provided regarding the objectives of the modeling effort, uncertainties, limitations, and insight gained through the effort. The TM also presents the results of a biodegradation analysis completed together with the numerical modeling to estimate the time needed for the contaminant plume off of the BWP property to reach ARAR concentrations.

The primary purpose of this analysis is: (1) To evaluate the potential extent of contaminant migration under a number of remediation alternatives; and (2) To evaluate natural biodegradation attenuation and estimate the range of time to remediate the dissolved plume north of the north boundary cutoff (NBC) system.

The modeling effort described in this TM is limited to the following:

- Data search to obtain the needed data to develop the models
- Development of a simplified conceptual model of the model domain area
- Construction of a numerical flow model based on the simplified conceptual model using MODFLOW
- Construction of a particle tracking model using PATH3D on the flow model output
- Use of the model to evaluate different remediation scenarios
- Estimating time required to reach ARAR's concentration in the plume off of the BWP property.

Because of limited data in the area of concern and budget constraint, the modeling effort did not involve complete solute transport analysis.

Modeling Objectives

The BWP Property and the impacted area to the north are shown on Figure 1. A plume of dissolved contamination has moved from the BWP Property downgradient to the north of the property. This plume has moved in the surficial aquifer, which is defined as the alluvium and the underlying weathered Denver formation (the Denver formation is defined as the unweathered Denver and was not included in the model). The groundwater flow direction in the surficial and Denver aquifers is to the north-northeast. The modeling effort included construction of groundwater flow and particle tracking models. The objectives of the modeling effort were as follows:

- To use the available data to create a conceptual model of the area off of the BWP property (assuming the soil/bentonite cutoff wall and the NBC system are active) and to simulate groundwater flow and advective contaminant migration

- To evaluate the relative effectiveness of four proposed remedial alternatives; identify data gaps; and, if possible, extrapolate the alternatives' impacts into the future. The alternatives were:

  - Natural attenuation with monitoring: The impact of natural attenuation on the contaminants north of the property once the source is cut off

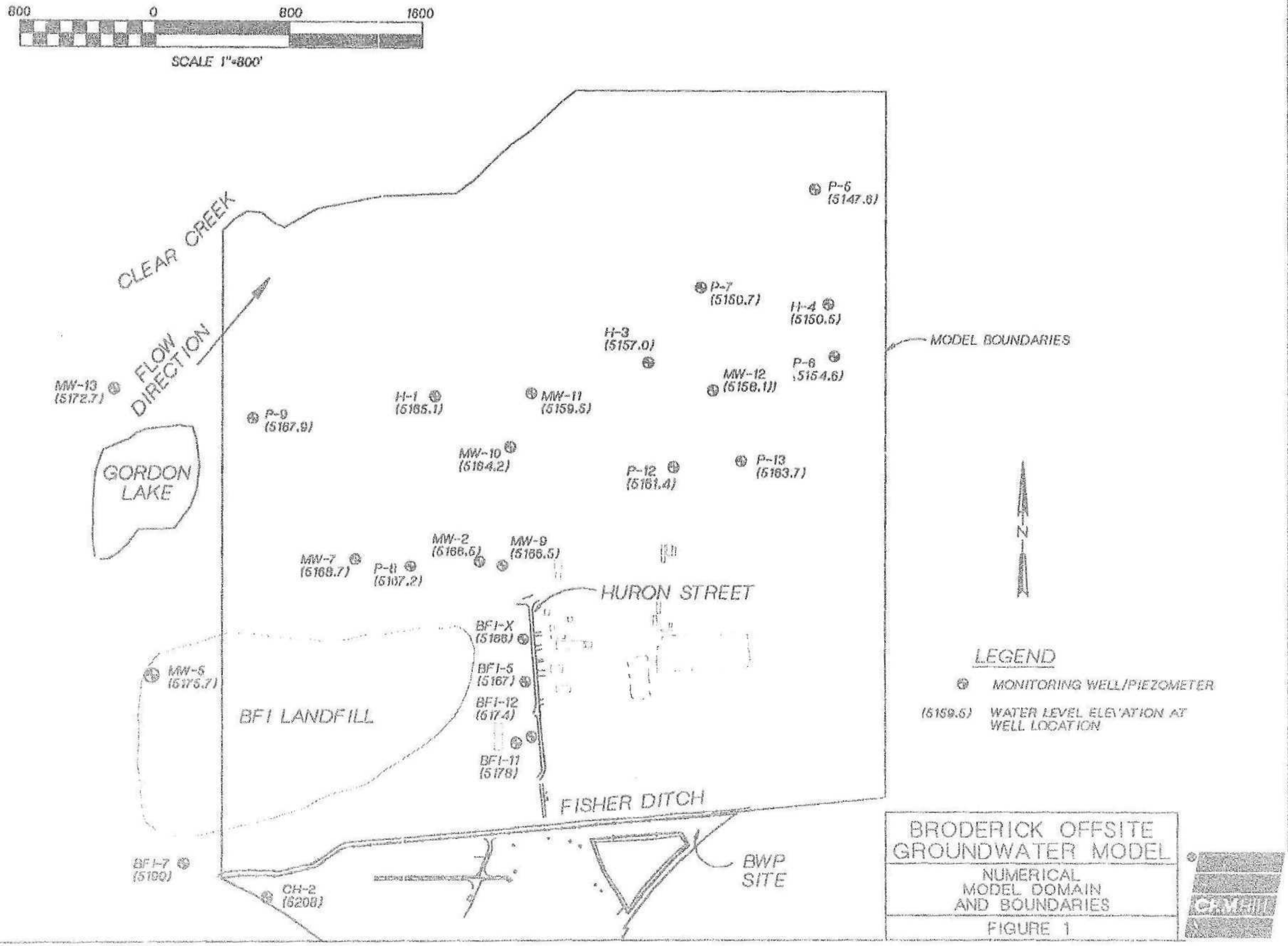
  - Pump and treat: Installation of a pump and treat system along Huron Street

  - Pump and treat: Installation of a line of pumping wells situated perpendicular to Huron Street and south of 62nd Street designed to intercept the northern edge of the dissolved plume.

  - Pump and treat: Installation of pump and treat wells along a 100-foot grid system throughout the plume area.

The natural attenuation processes included in this analysis are reduction of plume concentration through advection and aerobic biodegradation. Other natural attenuation processes such as diffusion and chemical transformation were not considered.

Numerical modeling was chosen as the appropriate tool for this effort because it has the capability to represent multidimensional flow in a heterogeneous system with less conceptual idealization than is required by other analytical techniques. While analytical solutions are available, numerical modeling offers the most accurate way of representing the available data. Additionally, as more data were available the model was modified to reflect the additional data. However, it was recognized from the outset that there will



BRODERICK OFFSITE GROUNDWATER MODEL

NUMERICAL MODEL DOMAIN AND BOUNDARIES

FIGURE 1

always be some uncertainty in the hydrogeologic understanding of the site and that the modeling analysis can only provide approximate answers.

The process of developing a numerical model of a complex physical system requires that simplifying assumptions be made to reflect the uncertainties in the definition of the site characteristics. Site characteristics that are routinely simplified for the purpose of numerical analysis are the temporal and spatial variability of aquifer properties, and the temporal variation in recharge and groundwater pumping.

For the modeling effort, the following are the most significant assumptions made:

- The aquifers at the BWP site are homogenous and of varying thickness.
- The distribution of recharge over time and space is constant.
- No future hydrologic conditions will affect the remediation scenarios.
- The impact that the BFI landfill may have on the hydrogeologic system and the contaminant plume was not considered.

This TM provides a summary of the numerical modeling procedures and the results as they pertain to the previously listed objectives. A description of the MODFLOW and PATH3D numerical code is provided in the models' documentation (McDonald and Harbaugh, 1988 for MODFLOW, and Papadopulos & Associates, Inc, 1991 for PATH3D).

Site Conceptual Model

The first step in the analytical process is to select the essential features of the site that must be considered and to identify how they can be represented in the numerical analysis. This procedure results in a conceptual model of the site, which then forms the framework for construction of the numerical model.

The essential features of the hydrologic system at the BWP site included in the numerical model are:

- Alluvium composed of the alluvial terrace material present on the BWP property and just north of the BWP property; and alluvium composed of Clear Creek flood plain material present north of the BWP property.
- Weathered Denver aquifer.
- Fisher Ditch.

- Clear Creek.
- Recharge of precipitation to the groundwater system.

The unweathered Denver aquifer was not included in the model. Figure 2 shows the essential features of the conceptual model. Although other documents combine the alluvial aquifer and the weathered Denver aquifer into one aquifer (the surficial aquifer), they are discussed and modeled as separate units in this TM due to their different hydraulic properties.

The principal sources of recharge to the model area are percolation from Fisher Ditch and deep percolation of precipitation in the Clear Creek alluvial deposits. Recharge was considered a calibration parameter and was varied to obtain a good visual fit between predicted heads and target heads. The site conceptual model was based on available information and no pumping is known to affect groundwater flow in the area.

Estimates of the saturated thickness (bottom of aquifer and water level elevations) were obtained from two sources: (1) site investigation (EPA 1994), (BIC, 1990) and (2) Colorado Department of Transportation (CDOT) I-76 project (Welsh, 1991) (Figures 3, 4, and 6). Aquifer hydraulic conductivities are based on limited field data and are shown on Figure 5.

Numerical Model Construction

The flow model is a numerical representation of groundwater flow in the two units. Elements of the model are discussed in the following sections.

Code Selection

The primary computer code used for numerical modeling to simulate flow was the USGS MODFLOW (McDonald and Harbaugh, 1988) code distributed by the International Ground Water Modeling Center (IGWMC), Version 3.2 with the rewetting capabilities. MODFLOW was selected because it is a publicly available, well documented, highly reliable, and extensively used three-dimensional finite-difference groundwater flow code developed by the U.S. Geological Survey (USGS). The code is capable of simulating transient and steady-state flow in combinations of confined, unconfined, and semiconfined aquifers with a variety of boundary conditions. The model is considered highly reliable as a numerical solver of the basic equations of saturated flow in porous media.

The particle tracking program used for calculating groundwater paths and travel times is the Papadopolus PATH3D (Papadopolus, 1991) code, also distributed by the IGWMC. This code is also well documented and considered highly reliable.

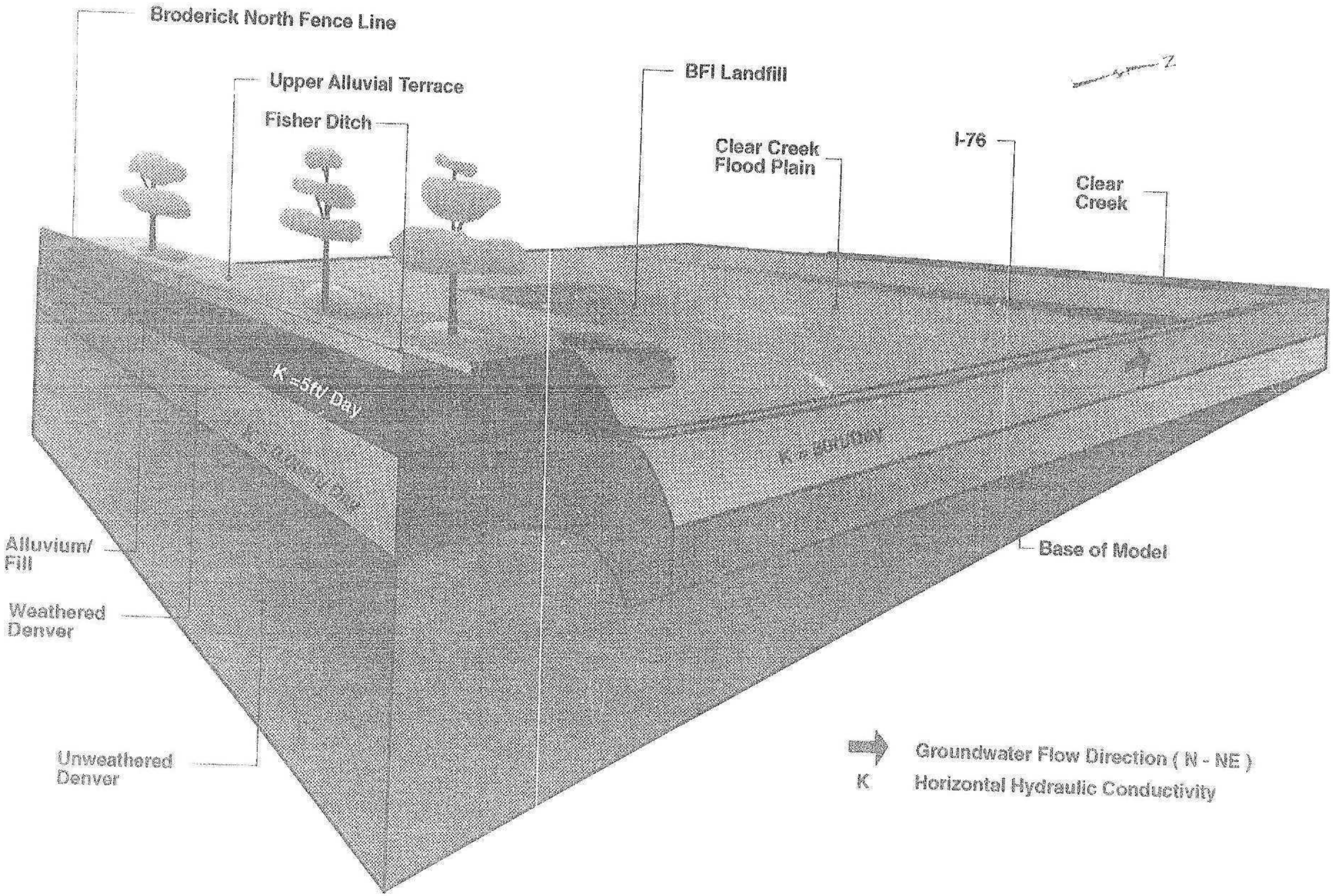
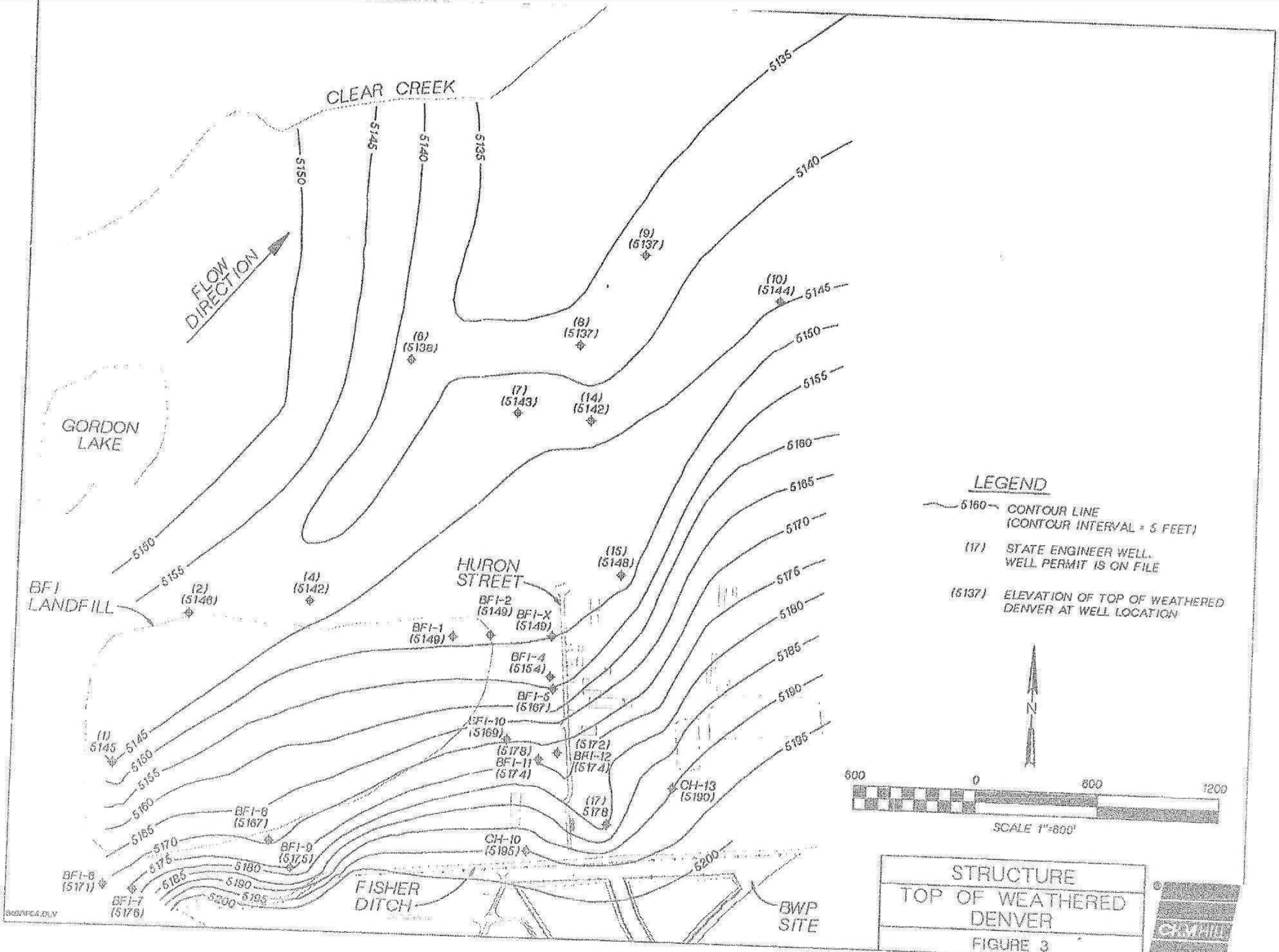
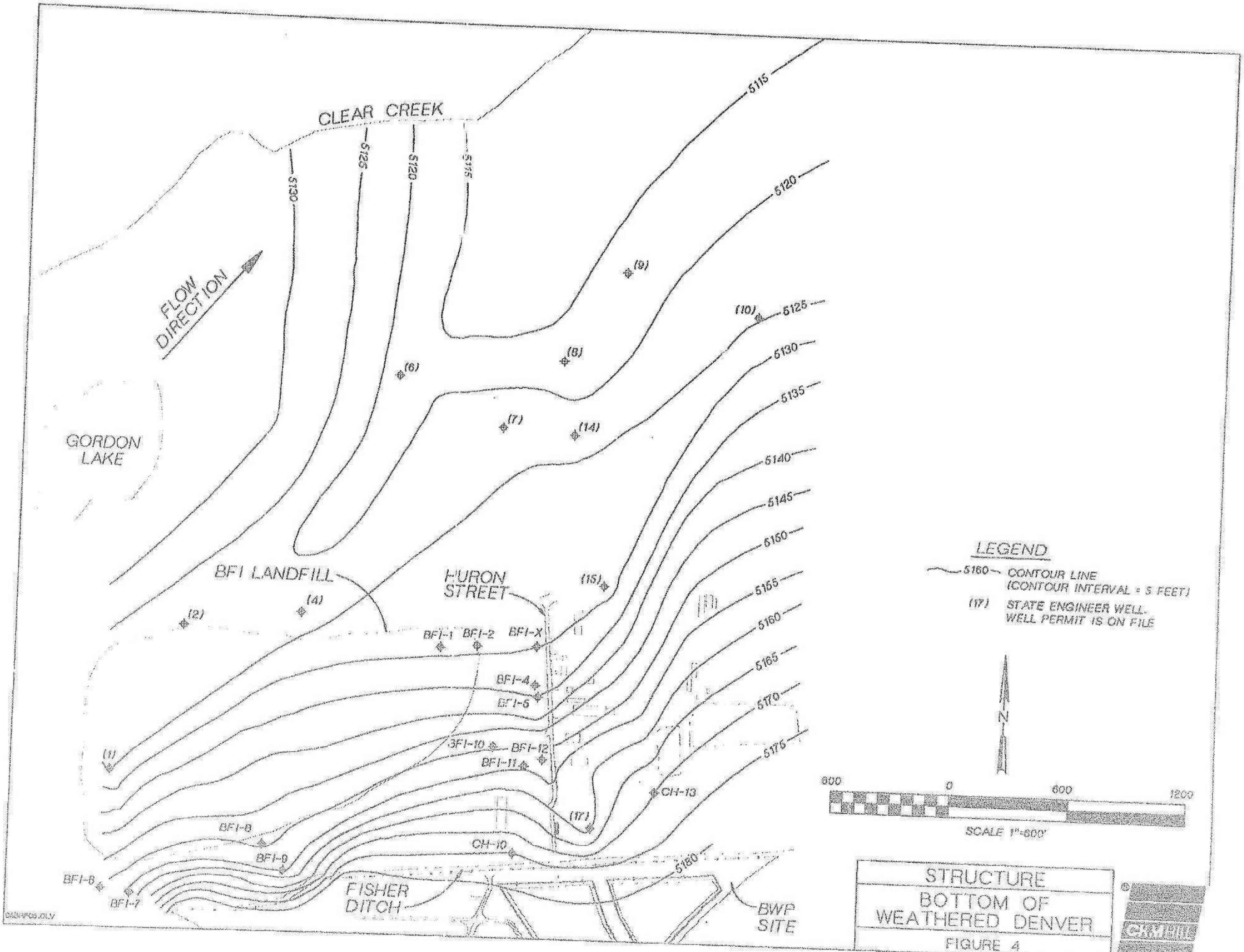


Figure 2
Generalized Hydrologic System



STRUCTURE
TOP OF WEATHERED DENVER
FIGURE 3


CLEAR CREEK
FLOW DIRECTION
GORDON LAKE
BFI LANDFILL
HURON STREET
FISHER DITCH
BWP SITE
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5125
5130
5135
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5145
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5155
5160
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5180
(1)
(2)
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(8)
(9)
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(17)
BFI-1
BFI-2
BFI-X
BFI-4
BFI-5
BFI-10
BFI-12
BFI-11
BFI-8
BFI-9
BFI-6
BFI-7
CH-10
CH-13
LEGEND
5160 CONTOUR LINE (CONTOUR INTERVAL = 5 FEET)
(17) STATE ENGINEER WELL. WELL PERMIT IS ON FILE
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600
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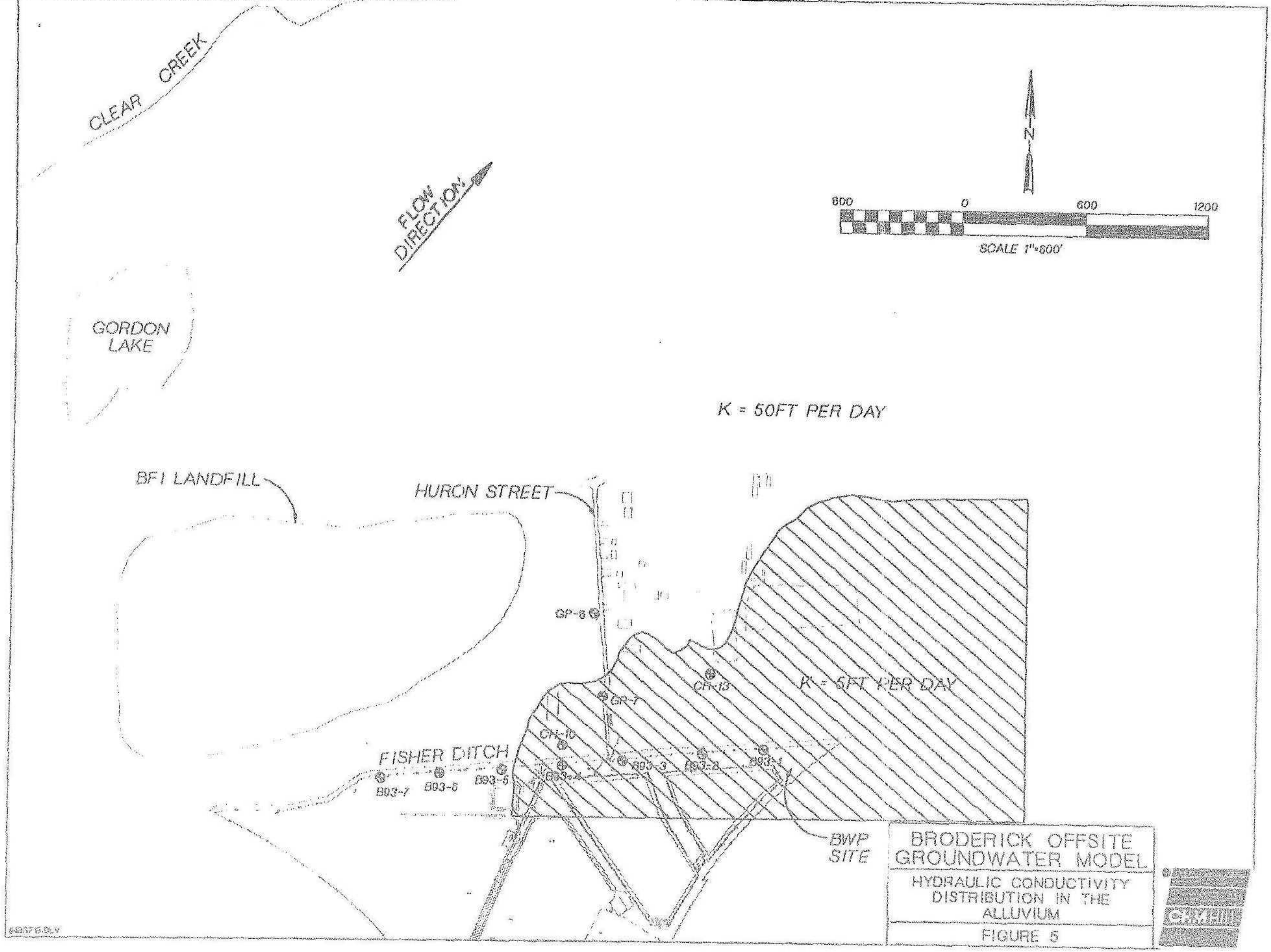
1200
SCALE 1"=600'
STRUCTURE
BOTTOM OF WEATHERED DENVER
FIGURE 4
CH2MHILL


CLEAR CREEK
FLOW DIRECTION
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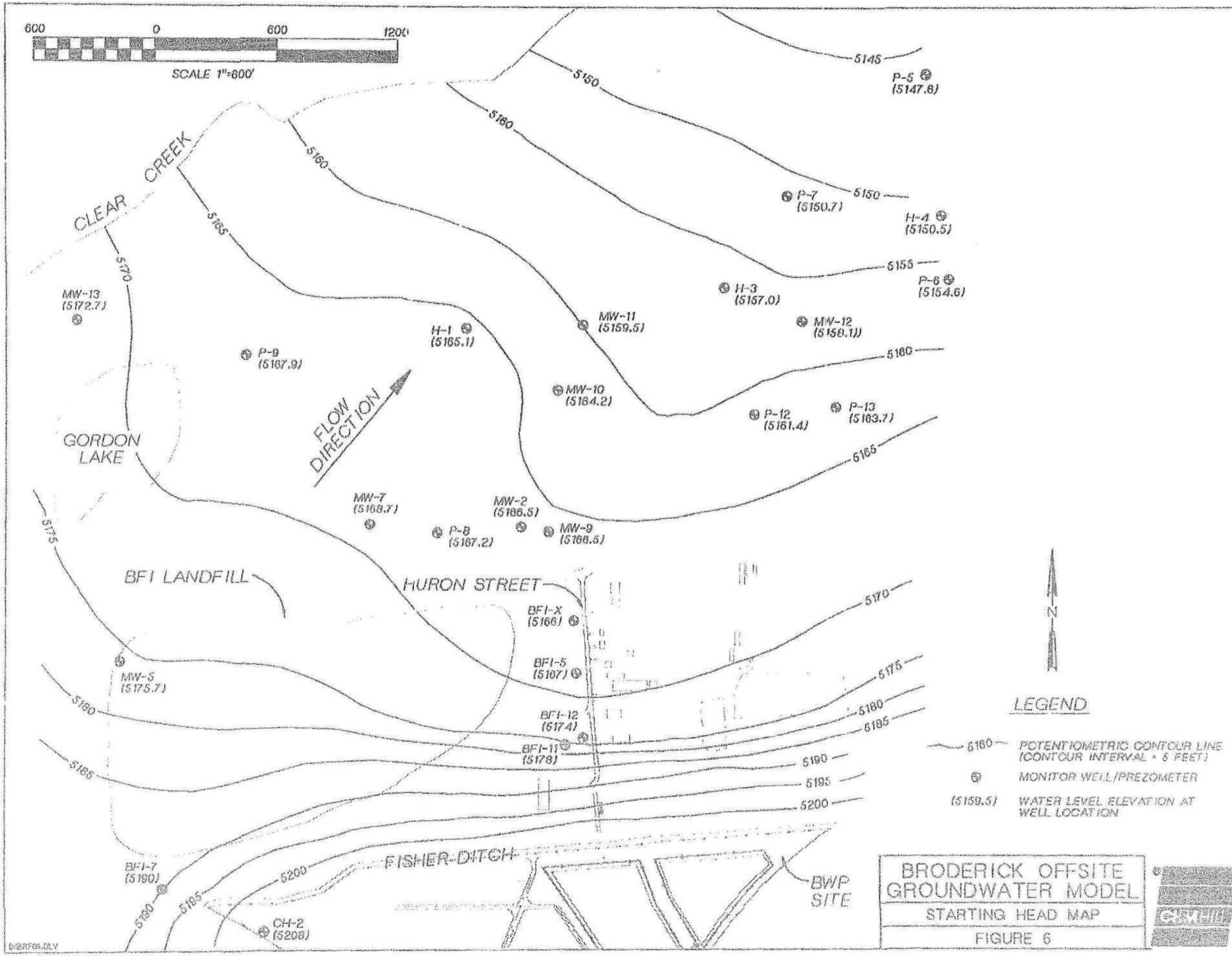
600 0 600 1200
SCALE 1"=600'
GORDON LAKE
K = 50FT PER DAY
BFI LANDFILL
HURON STREET
GP-6
GP-7
CH-13
K = 5FT PER DAY
CH-10
FISHER DITCH
B93-7
B93-6
B93-5
B93-4
B93-3
B93-2
B93-1
BWP SITE
BRODERICK OFFSITE GROUNDWATER MODEL
HYDRAULIC CONDUCTIVITY DISTRIBUTION IN THE ALLUVIUM
FIGURE 5


600 0 600 1200
SCALE 1"=600'
CLEAR CREEK
GORDON LAKE
FLOW DIRECTION
BFI LANDFILL
HURON STREET
FISHER DITCH
BWP SITE
P-5 (5147.6)
P-7 (5150.7)
H-4 (5150.5)
H-3 (5157.0)
P-6 (5154.6)
MW-12 (5158.1)
MW-11 (5159.5)
MW-13 (5172.7)
H-1 (5165.1)
P-9 (5167.9)
MW-10 (5164.2)
P-12 (5161.4)
P-13 (5163.7)
MW-7 (5168.7)
MW-2 (5166.5)
P-8 (5167.2)
MW-9 (5166.5)
BFI-X (5166)
BFI-5 (5167)
MW-5 (5175.7)
BFI-12 (5174)
BFI-11 (5178)
BFI-7 (5190)
CH-2 (5208)
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LEGEND
5160 POTENTIOMETRIC CONTOUR LINE (CONTOUR INTERVAL = 5 FEET)
MONITOR WELL/PIEZOMETER
(5159.5) WATER LEVEL ELEVATION AT WELL LOCATION
BRODERICK OFFSITE GROUNDWATER MODEL
STARTING HEAD MAP
FIGURE 6
CH2M HILL
B4BRF06.DLV

Finite Difference Grid Delineation and Boundary Conditions

The numerical model developed for the area north of the BWP Property was developed in accordance with the site conceptual model discussed previously. A two-dimensional finite-difference grid with 108 rows and 100 columns was constructed for each of the two model layers. A uniform grid spacing of 45 feet was used for rows and 40 feet for columns, with the exception of rows 1 through 4 and rows 105 through 108. For those rows the grid size varied from 135 feet for rows 1 and 108 to 65 feet for rows 4 and 105. This was necessary to cover the model domain with 108 rows while maintaining the required grid size increase of 1.5. The areal extent of the model is illustrated in Figure 2.

Boundary conditions define the interactions between heads located within the modeled area and groundwater conditions outside the model area. To the south at the boundary with the BWP Property a constant flux was imposed to simulate leakage from Fisher Ditch. To the north, a constant head boundary was imposed along Clear Creek. No boundary conditions are explicitly defined at the eastern and western edges of the model grid, such that no-flow conditions are implicitly assigned by MODFLOW. Input to this model requires water levels at the boundary of the model. The lower boundary condition for this model is automatically assigned to be no-flow by the model.

Initial Parameters Selection

The flow and tracking models are three-dimensional flow models of confined/unconfined groundwater flow. For both steady and transient state simulations, a value for hydraulic conductivity at each model node was required as input. Available information was considered in estimating the distribution of aquifer properties in each of the two model layers. The aquifer parameters used in the initial construction of the model were based on the best estimates derived from available field measurements, testing, and literature.

The bottom and top elevations and water levels of the two aquifers vary across the model area. Structure maps of the bottom and top elevation of the two aquifers were produced by contouring measured elevation values obtained from site investigation and from the CDOT I-76 project using a computer program called SURFER (Figure 3 and 4). This description of bottom and top was held constant.

For the top layer, two hydraulic conductivity zones were defined to account for the difference between the hydraulic conductivity of the upper alluvial terrace and that of the Clear Creek floodplain. Hydraulic conductivity values for the upper alluvial terrace and the weathered Denver were obtained from field testing completed at the BWP site. Values for Clear Creek floodplain were obtained from the literature. The XYZ data were transformed into a 108 $\times$ 100 grid that was imported into the model. In the calibration stage of the modeling process this parameter was slightly modified through iterative adjustment of the model to obtain a good fit between predicted and observed heads.

The conceptual model of groundwater flow includes leakage upward and downward. This was incorporated by specifying a leakage term between layers. The value of this parameter is a function of the conductance of each layer, which is a function of average vertical hydraulic conductivity between layers and the thickness of the layers.

The vertical leakance was computed using the following equation:

$$VC = 1/(d_1/k_{v1} + d_2/k_{v2}) \tag{1}$$

where:

VC	=	the vertical conductance between Layer 1 and Layer 2
d_1	=	the thickness of Layer 1
k_{v1}	=	the vertical hydraulic conductivity of Layer 1
d_2	=	the thickness of Layer 2
k_{v2}	=	the vertical hydraulic conductivity of Layer 2

The value of the vertical hydraulic conductivity (k_v) was assumed to be 10 percent of that of the horizontal hydraulic conductivity to satisfy an anisotropy ratio of 1 to 10.

Calibration and Sensitivity Analysis

Calibration

Model calibration is an interactive process in which certain model parameters are adjusted to produce predicted groundwater elevations that closely match observed conditions. For the BWP model, the objective was to develop a numerical representation of the site's general features and use the representation to compare different scenarios.

Usually during the calibration process, the parameters adjusted are those that have not been accurately measured in the field and that can have a strong influence on the simulation results. Three model input parameters that were varied during the calibration process are:

- The hydraulic conductivity of the Upper Alluvial Terrace and the Weathered Denver.
- Areal recharge applied to the Clear Creek floodplain.
- Fisher Ditch leakage rate.

The calibration process requires that an appropriate set of water level measurements be available to serve as a target for adjustment of the model calibration parameters. A set of water level data (from the RI, recent measurements, 8/93, and CDOT I-76/ I-25 Interchange to the north and east of the BWP Property, 6/91) was used for calibration (Figure 6). The following goals were used in the calibration of the model:

- The model should yield the same water level distribution configuration as the target water levels.
- The model should accurately depict the overall gradient within the model domain.

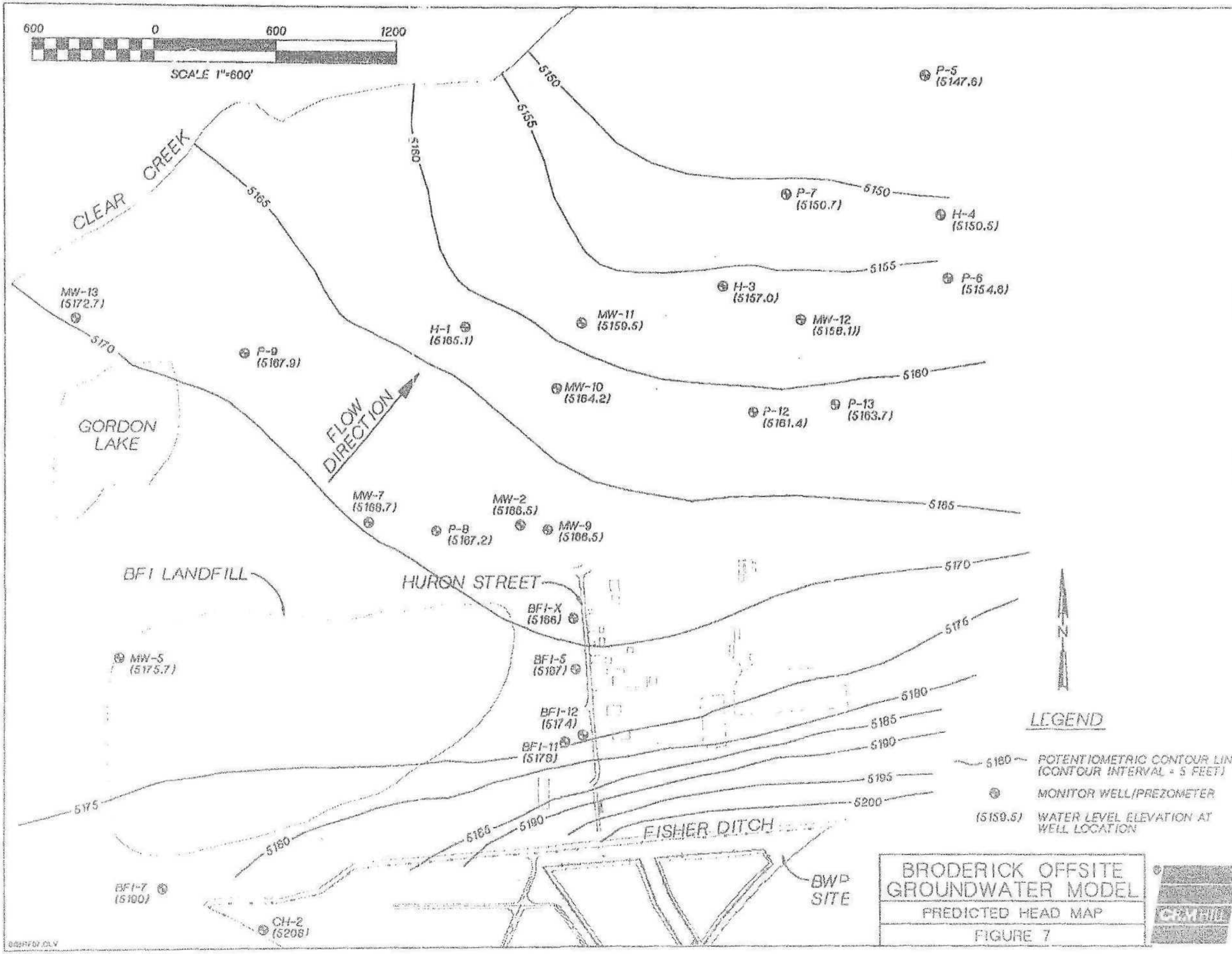
Matching the exact location of each contour was not considered an important calibration criteria because of the uncertainty in the data. The water level data were drawn from two separate sets of water levels.

A recharge value of 2.2 inches per year was necessary to achieve the calibration goals discussed above. This is a slightly higher percentage than generally used (10 percent of precipitation used as a rule of thumb for sites nationwide). The average precipitation in the Denver area is about 14 inches. However, this could be attributed to the nature of the floodplain, the flat and depressed topography, and Fisher Ditch seepage to the vadose zone which percolates to groundwater and also produce seeps downgradient of the ditch.

The simulated potentiometric surface is presented in Figure 7. In general, by comparing Figure 6 and 7, it appears that the simulated heads are within a reasonable range of the target heads. As indicated in Figure 7, the predicted heads are higher than observed heads at MW-13, BFI-X, and BFI-5. The predicted heads are lower than observed head at BFI-11. It is important to notice that this is the area where the two sets of water level data border. The two water level data sets were taken on June 1991 and August 1993. The 1991 data span the north area of the site and also contain MW-5. The 1993 data covers the southern portion of the site. MW-5 water level elevation, which is part of the 1991 data, is in agreement with the 1993 water level elevation. However, BFI-X and BFI-5, which are part of the 1993 data, have water level elevations that are lower than MW-7 and P-8, which are located downgradient of BFI-X and BFI-5. The residual mean square (RMS) for the entire model is 4.5 feet.

Sensitivity Analysis

Sensitivity analysis is frequently used to study the sensitivity of model results to changes in input parameters. This is done, even though the model may be well calibrated, because it is recognized that the calibration may not be unique. There may be more than one combination of parameters that produces equally good agreement between simulation results and field measurements. The normal procedure for sensitivity analysis is to vary individual input parameters, such as hydraulic conductivity, and to observe the amount of



600 0 600 1200
SCALE 1"=600'
CLEAR CREEK
GORDON LAKE
FLOW DIRECTION
BFI LANDFILL
HURON STREET
FISHER DITCH
BWD SITE
P-5 (5147.6)
P-7 (5150.7)
H-4 (5150.5)
H-3 (5157.0)
P-6 (5154.8)
MW-11 (5159.5)
MW-12 (5158.1))
MW-13 (5172.7)
H-1 (5165.1)
P-9 (5167.9)
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P-12 (5161.4)
P-13 (5163.7)
MW-7 (5168.7)
MW-2 (5166.5)
P-8 (5167.2)
MW-9 (5166.5)
BFI-X (5166)
MW-5 (5175.7)
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BFI-12 (5174)
BFI-11 (5178)
BFI-7 (5190)
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LEGEND
5160 POTENTIOMETRIC CONTOUR LINE (CONTOUR INTERVAL = 5 FEET)
MONITOR WELL/PREZOMETER
(5159.5) WATER LEVEL ELEVATION AT WELL LOCATION
BRODERICK OFFSITE GROUNDWATER MODEL
PREDICTED HEAD MAP
FIGURE 7

resulting variation in simulation results. The resulting information may help quantify the degree of uncertainty associated with the model results.

Sensitivity simulations were performed to identify a reasonable range for each of the calibrated parameters. A parameter value was considered to be unreasonable if it did not seem plausible on the basis of existing data and literature, or if any of the calibration criteria above could not subsequently be met by adjusting the values of the other two calibration parameters. The results indicated that the input parameters were reasonable and were therefore incorporated into the model. Figures 8 through 11 show the results of sensitivity analysis for values of hydraulic conductivity and recharge equal to half and twice the calibrated values. The results indicated that the model results are not sensitive to these parameters.

Scenario Runs

Four scenario runs were considered for evaluation:

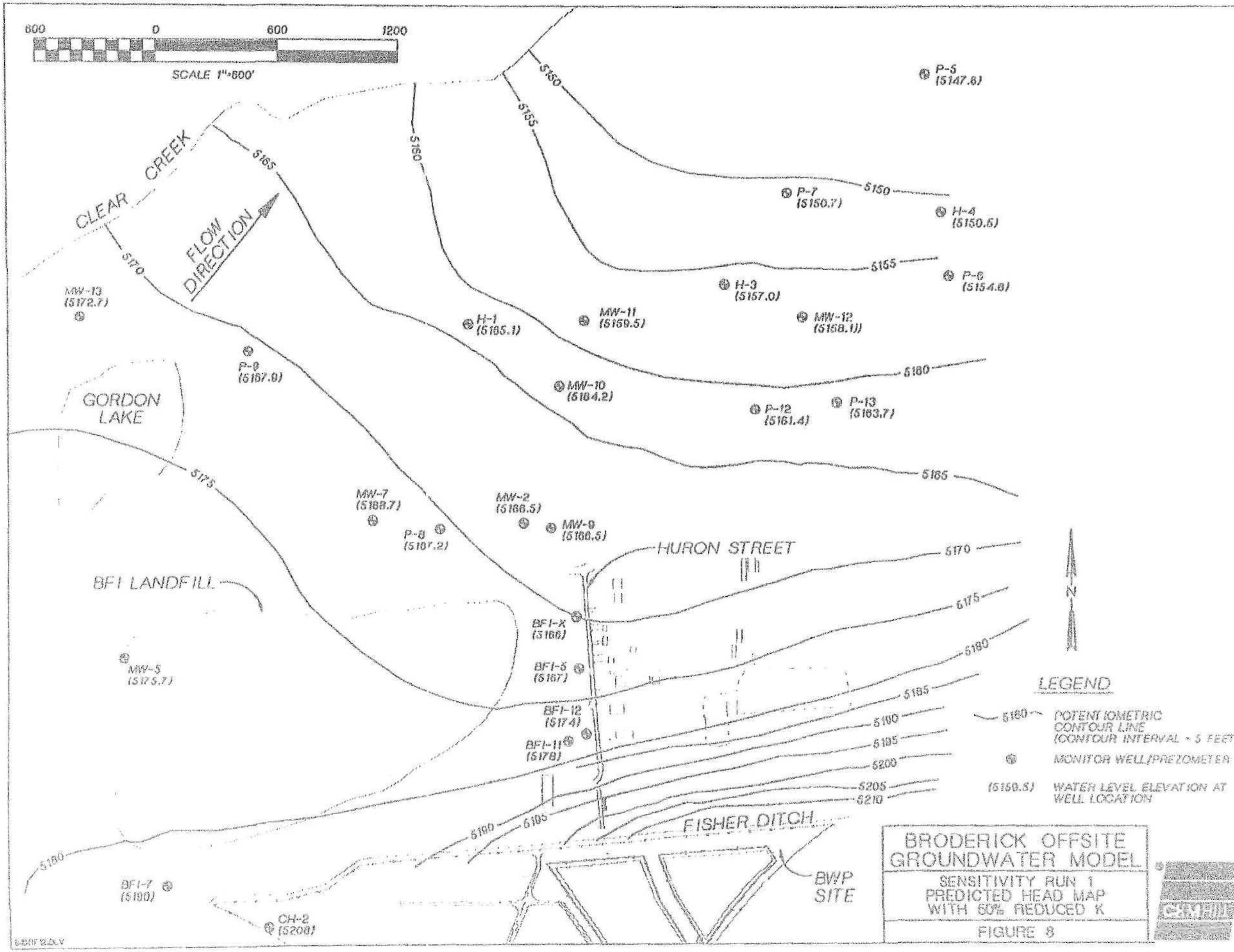
- The results of natural attenuation on offsite contamination once the BWP source is cut off.
- The impact of a pump and treat extraction system along Huron Street on offsite contamination.
- The impact of a pump and treat extraction system located perpendicular to the flow direction at the leading edge of the offsite contaminant plume.
- The impact of a pump and treat extraction system located on a 100-foot grid in the plume area.
- The wall and NBC are operational and cutting off groundwater flow from the site.

It was assumed in the scenario simulations that the groundwater elevations across the model area are not affected by current onsite remediation efforts.

The saturated thickness of certain portions of the Upper Alluvial Terrace may decrease or the aquifer may become completely de-watered around the remedial wells. If this occurs, remediation using extraction wells will become ineffective.

Biodegradation Analysis

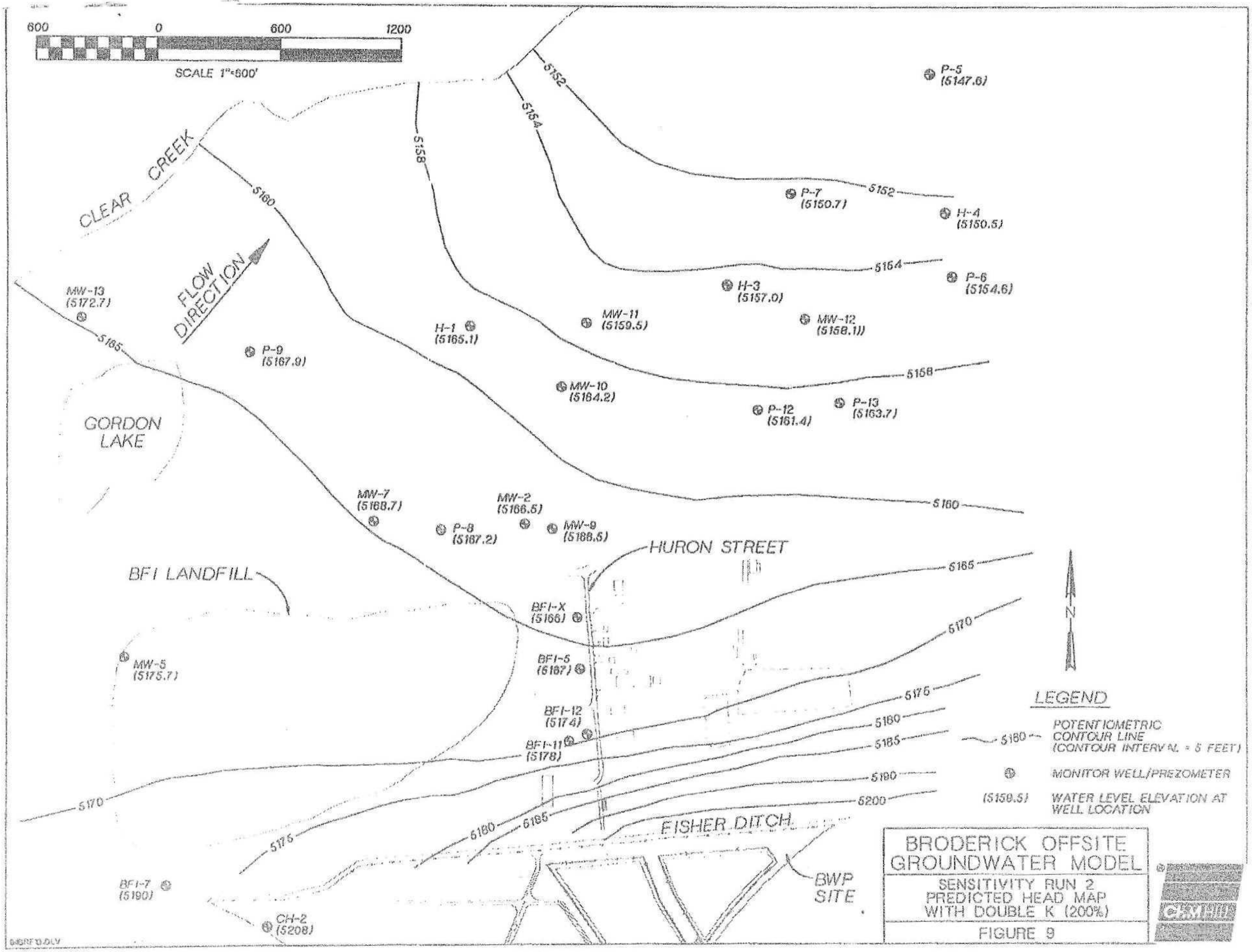
The following describes the biodegradation analysis conducted for the area north of the BWP Property. The following is a list of assumptions used in the analysis.



BRODERICK OFFSITE GROUNDWATER MODEL

SENSITIVITY RUN 1 PREDICTED HEAD MAP WITH 60% REDUCED K

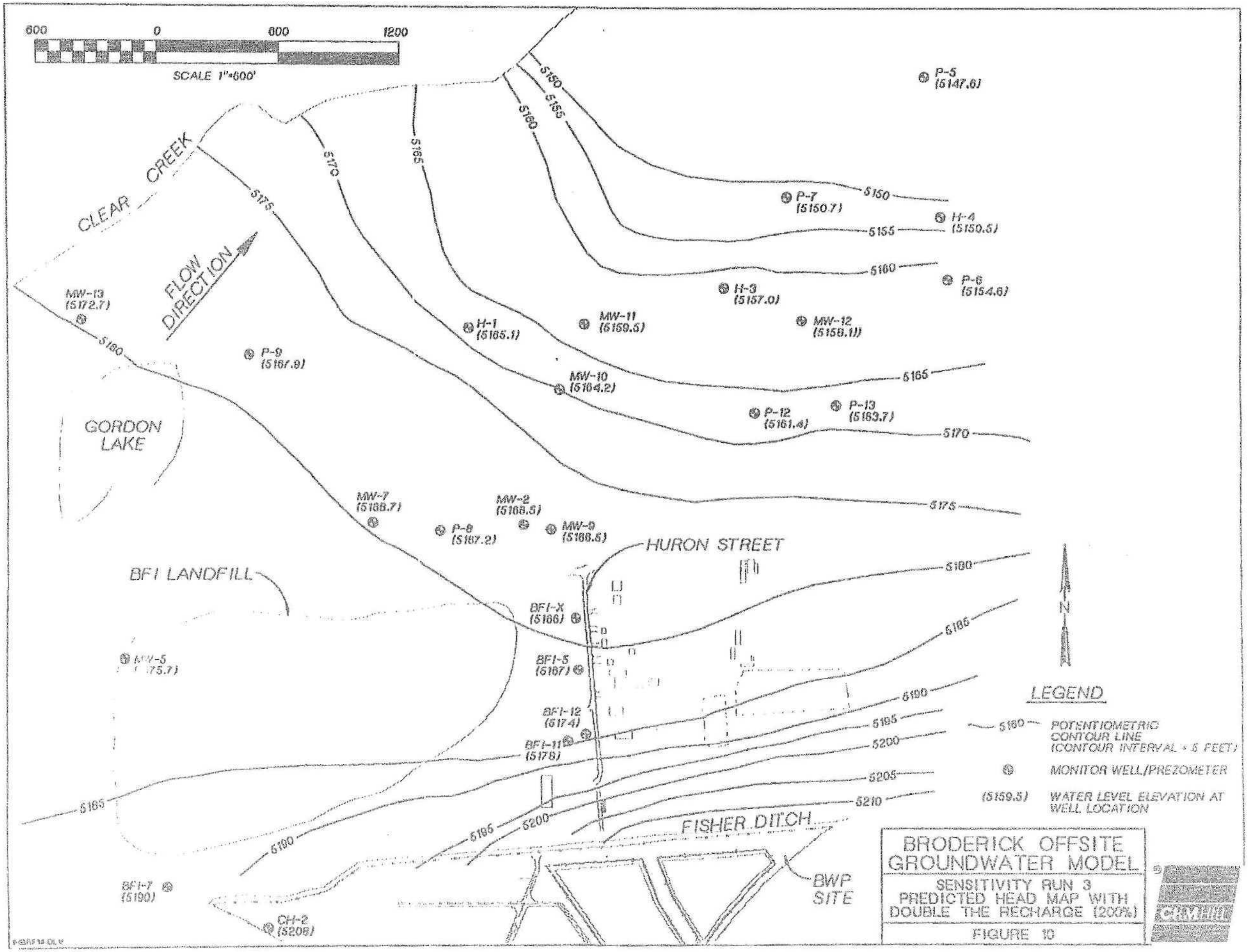
FIGURE 8



BRODERICK OFFSITE GROUNDWATER MODEL

SENSITIVITY RUN 2
PREDICTED HEAD MAP
WITH DOUBLE K (200%)

FIGURE 9



600 0 600 1200
SCALE 1"=600'
CLEAR CREEK
FLOW DIRECTION
GORDON LAKE
BFI LANDFILL
HURON STREET
FISHER DITCH
BWP SITE
MW-13 (5172.7)
P-9 (5167.9)
H-1 (5165.1)
MW-11 (5159.5)
H-3 (5157.0)
MW-12 (5158.1)
P-5 (5147.6)
P-7 (5150.7)
H-4 (5150.5)
P-6 (5154.6)
MW-10 (5164.2)
P-12 (5161.4)
P-13 (5163.7)
MW-7 (5168.7)
MW-2 (5168.5)
P-8 (5167.2)
MW-9 (5166.5)
BFI-X (5166)
BFI-5 (5167)
BFI-12 (5174)
BFI-11 (5178)
BFI-7 (5190)
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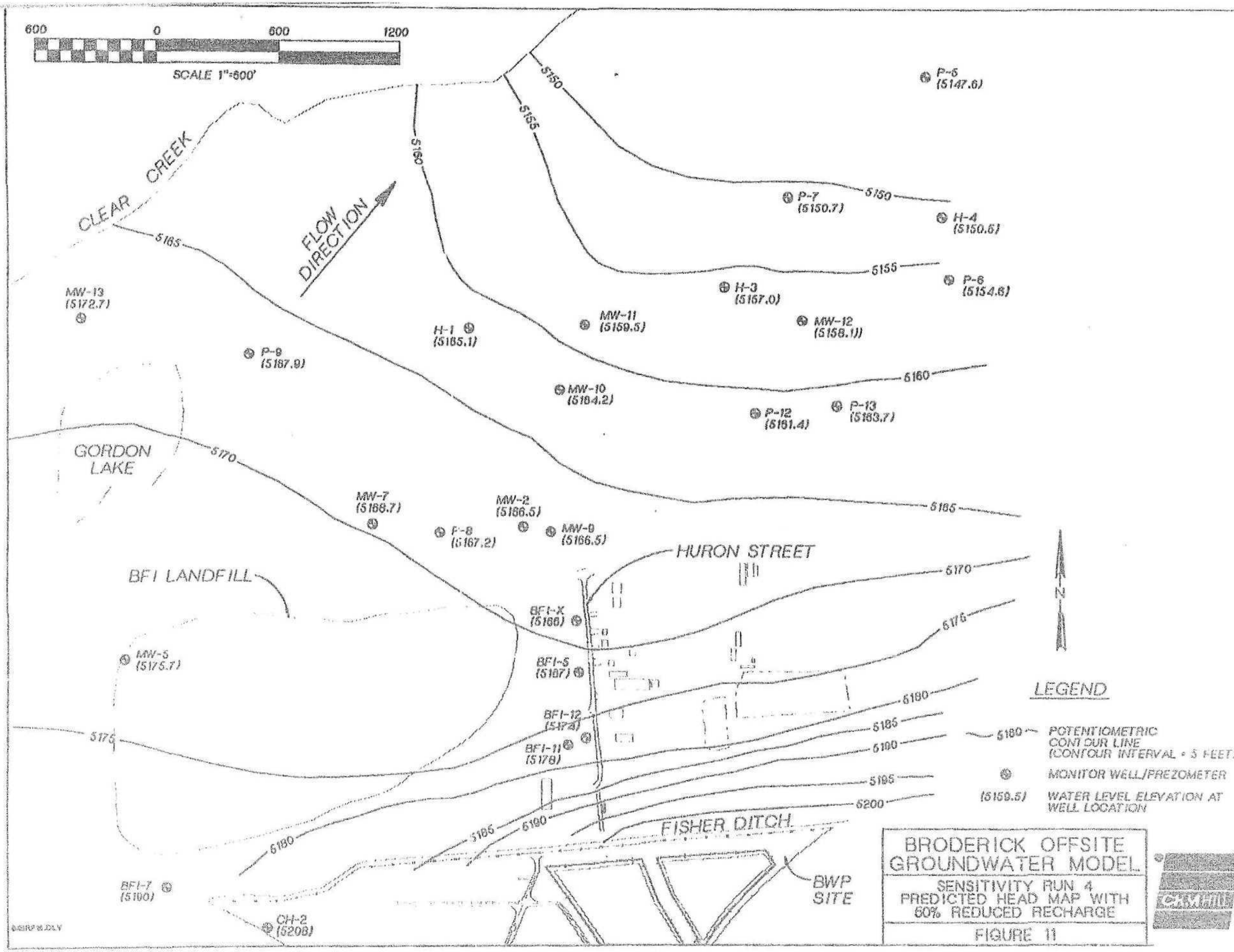
LEGEND
5160 POTENTIOMETRIC CONTOUR LINE (CONTOUR INTERVAL = 5 FEET)
MONITOR WELL/PREZOMETER
(5159.5) WATER LEVEL ELEVATION AT WELL LOCATION
BRODERICK OFFSITE GROUNDWATER MODEL
SENSITIVITY RUN 3 PREDICTED HEAD MAP WITH DOUBLE THE RECHARGE (200%)
FIGURE 10
CH2M HILL



BRODERICK OFFSITE GROUNDWATER MODEL
SENSITIVITY RUN 4 PREDICTED HEAD MAP WITH 60% REDUCED RECHARGE
FIGURE 11

- PCP was used as the primary contaminant of concern. Reasons for using PCP included:

  - It has the lowest target concentration (drinking water standard) of the common wood preserving contaminants (1 ppb)

  - It has a higher solubility and is therefore more mobile than the common wood preserving contaminants

  - It is the only wood preserving contaminant consistently observed in relatively high concentrations in the wells north of the BWP Property

- Aerobic biodegradation is the primary biodegradation route for PCP. Natural anaerobic biodegradation has been observed at some sites, but in order to be conservative it will not be considered here. Evidence for natural biodegradation can be found in the following literature: Davis, 1994; Smith, 1987; Mudsen, 1991; Bedient, 1984; Ehrlich, 1982; Goerlitz, 1985.

- Oxygen supply limits the rate of PCP biodegradation. The slow rate of water movement in the subsurface should provide adequate "retention time" for PCP biodegradation, if adequate oxygen is present.

- The "front end" of the PCP plume will mix with clean groundwater that should have high dissolved oxygen concentration as the plume tries to move to the north. The "backend" of the plume will mix with Fisher Ditch recharge water that also has a high dissolved oxygen. The result will be that the plume will be attacked from two ends and should gradually shrink in size.

- Average PCP concentration in the offsite plume is 528 ppb. This is a high concentration obtained by averaging the highest measured concentration of all the sampling events. In the case of nondetect values the detection limit concentration was used. Figure 1 presents the numbers used.

- Dissolved contamination is the only "phase" of contamination present offsite. No oily phase contaminant has been observed north of Fisher Ditch.

- A plume area of 1.852×10^6 ft^2 based on the 1 ppb concentration contour from the Additional Studies (AS) Report (EPA, 1994) (see Figure 1).

- A void ratio of 30 percent.

- Aquifer saturated thickness of 20 feet.

- Only 10 percent of the water that infiltrates from Fisher Ditch actually contacts the contaminant plume. This a conservative assumption.

- Fisher Ditch contribution to the offsite groundwater is 0.12 cfs or 1 percent of Fisher Ditch measured total flow.

- Fisher Ditch water oxygen concentration is 7 mg/L as measured in the field.

- Oxygen present in precipitation recharge water was not considered.

- Twenty percent of the total organic content (and thus, oxygen demand) in the groundwater comes from PCP. PCP is typically greater than 75 percent of the total concentration of priority pollutants present in the plume. However, there are likely to be nonpriority pollutants in the groundwater that will exert an oxygen demand. Twenty percent is a reasonably conservative estimate.

- The oxygen demand 3.5 mg of the groundwater can be estimated by using a conversion factor of oxygen per mg of hydrocarbon (3.5 mg/mg). This is based on the stoichiometry of common hydrocarbon biodegradation and is conservative for PCP (AFCEE, 1992) (McCarty, 1988).

The concentrations of PCP that have been detected in the area of the dissolved plume are presented in Figure 1. These are the numbers that were used to develop the average PCP concentration that was input into the model. The numbers presented in Figure 1 are taken from historical data in the RI report and from data in the Additional Studies Report. Because of the different sources, it should be noted that the samples were collected over different time periods. However, it was felt that this would present a conservative concentration for the model. BFI-9 is a well on the landfill property that cannot currently be located; however, because of the important location of the well, historical data were averaged; the number is presented in Figure 1. The BFI-9 well has the highest concentration of any of the wells in Figure 1 and biases the average concentration for the dissolved plume in the conservative direction. With BFI-9 included in the average concentration for the dissolved plume, the average concentration is 528 ppb. Without BFI-9 the average concentration is 38 ppb.

In addition to these assumptions, other assumptions were made in regard to the groundwater flow and particle tracking modeling and extent of contamination. The modeling was used to estimate the areal extent of the 1 ppb plume assuming that no contamination is contributed from the landfill and that apart from the modeled contamination plume, concentrations are zero.

Land use in the area to the north of the BWP Property is mixed, ranging from private residential to light industrial to landfills. The area immediately north of the BWP Property and west of Huron Street is an old landfill. There are wells surrounding the landfill (the BFI series wells), and lithologic information from these wells was used in developing the computer models; however, water quality data are not currently available from the majority of these wells. Because of this absence of water quality data, assumptions were made regarding the impact the landfill has on plume movement and shape beneath or around the old landfill. These assumptions include:

- The shape of the dissolved plume beneath the landfill
- The extent of the dissolved plume is not beneath the landfill
- Contamination is not contributed by the landfill

Further characterization of the landfill and the plume in relation to the landfill are not part of this modeling effort.

A report prepared for the I-76/I-25 Interchange to the north and east of the BWP Property includes some well and water quality information (Walsh, 1991). This report shows two wells located just north of the BFI landfill on the western side of the model area that had detectable levels of PCP. The values are 25 ppb for MW-5 and 820 ppb for MW-6 (Walsh, 1991). These detected values differed by orders of magnitude over the two available sampling rounds and have not been reconfirmed. At this time, EPA is evaluating further exploration of these data; however, this is not being incorporated into this model at this time.

Furthermore, it is not known if preferential flow of groundwater exists and affects flow and transport in the modeled area. Because no data were available on preferential flow, the aquifers were assumed to be homogeneous.

Table 1 lists values for the parameters used in the biodegradation analysis. Table 1 also shows the biodegradation equation used in the analysis. Factors affecting the biodegradation analysis which are not measured accurately include the fraction of groundwater recharge from Fisher Ditch in contact with the contamination plume. Table 2 shows sensitivity analysis results. Table 2 lists the biodegradation time corresponding to the varied parameter value. The table only lists the value of the parameter that was changed; all other parameters were held constant. Other physical processes such as adsorption and diffusion will not have significant effects on the time needed to reach ARAR concentration.

Results

Predictive groundwater withdrawal simulations were performed with the groundwater model and the particle tracking model to assess the effects of remedial pumping located along Huron Street, perpendicular to Huron Street, and on a 100-foot grid in the contaminant plume. Results from those scenarios were compared to the baseline scenario where no remedial pumping is exercised. Pumping along Huron Street, although parallel to groundwater flow, was assessed because it is likely the most feasible remedial pumping

Table 1 Natural Attenuation Analysis Biodegradation Parameter Values Page 1 of 2		
Parameters	Values or Equations	Units
Groundwater Concentration	Cf[a] = 327 Ci = 533	ppb
Aquifer Porosity	n = 0.3	
Area Scale: 1 $inch^2$ = 486,005 $feet^2$	s = 476,005	$feet^2/inch^2$
Aquifer Thickness	b = 20	feet
Initial Area of Contamination in Inches	Ai = 2.34	$inch^2$
Area of Contamination after Dilution	Ad = 3.81	$inch^2$
Area of Contamination in $Feet^2$ after Dilution	Af = s × Ad Af = 1.852×10^6	$feet^2$
Volume of Contaminated Water	Vc = Af × b × n = 1.111×10^7	$feet^3$
Conversion from ppb to mg/L	Cm = 0.001	mg/L per ppb
Mass of Contamination in mg	m = Cm × Ci or Cf × Vc × 7.48 × 3.785 m = 1.027×10^8	mg
Oxygen Concentration in Water mg/L[b]	Wc = 7	mg/L
Oxygen Demand Percent of PCP	Od = 0.2	20 percent
Organics	Mg = 3.5[c]	mg of oxygen per milligram of organics
Flow of water in CFS	Q = 0.012	CFS

Table 1
Natural Attenuation Analysis
Biodegradation Parameter Values

Parameters	Values or Equations	Units
Flow of water in CFS	Q = 0.012	CFS
Flow of water in liters/day	Q = $0.012 \times 3600 \times 24 \times 7.48 \times 3.78$ Q = 2.931×10^4	liters/day
Time for Total biodegradation in days	T = $\frac{m \times Mg \times (1/Od)}{(Q \times Wc)}$ T = 8.754×10^3	days
Time in Years	Ty = T/365 Ty = 24	years

[a]Cf is final concentration after advective transport.
[b]As measured in field.
[c]From stoichiometry.

Notes:
- CFS = Cubic feet per second.
- $feet^2$ = Feet squared.
- $feet^3$ = Feet cubed.
- mg = Milligrams.
- mg/L = Milligrams per liter.
- ppb = Parts per billion.
- PCP = Pentachlorophenol.

Table 2 Biodegradation Sensitivity Analysis		
Recharge Water Oxygen Content (mg/L)	Recharge Water Percent in Contact With Contaminant (%)	Time to Complete Biodegradation (years)
7	10	24
7	25	10
7	50	5
7	5	48

alternative because of landuse and access issues. A modification to this alternative was proposed and consists of pumping from wells located perpendicular to groundwater flow and on 100-foot grid in the contaminant plume. All four scenarios include the following assumptions:

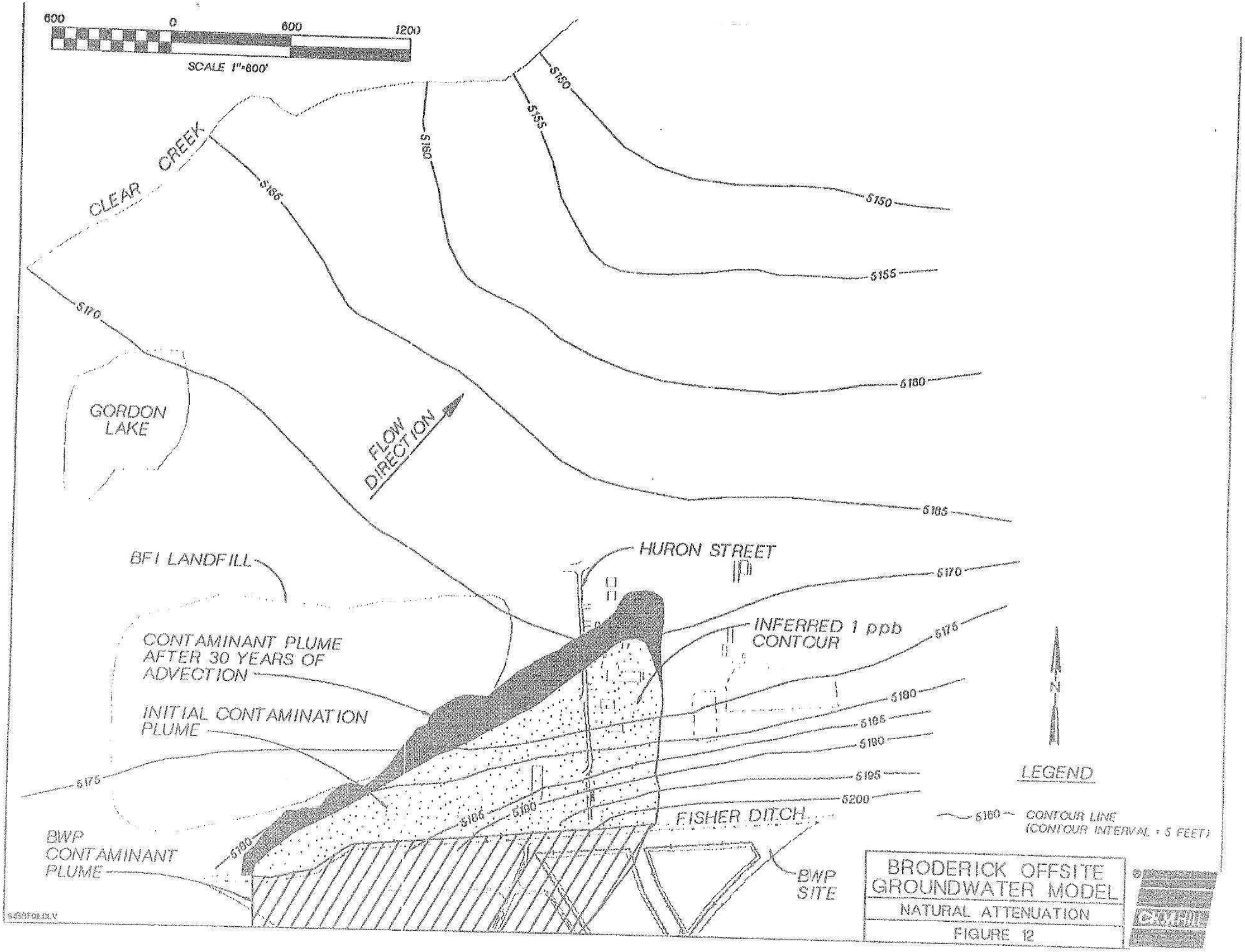
- Groundwater will not be developed in the offsite model domain (i.e., no pumping wells).

- Contaminant sources from the site will be effectively cut off by the NBC system and the slurry wall.

Figures 12 through 15 depict the groundwater potential surface and the predicted PCP plume at the start and end of the 30-year simulation period (assuming no biodegradation). All four figures indicate slow movement of the front. As a result, Scenario 2 pumping along Huron Street has essentially no impact on the contaminant front movement. As shown in the figures, pumping perpendicular to Huron Street will intercept contaminant migration along Huron Street but will not impact the movement of contaminants in the rest of the contaminant plume. The modeling also indicated contaminant movement toward the landfill. The front movement and the front shape are determined by the groundwater velocity and the assumed initial plume configuration. Variation of the groundwater velocity is caused by the hydraulic gradient. Scenario 4 pumping along 100 feet grid centered wells will slow the plume movement and will remove more contaminated water than the other scenarios.

If the contaminant plume is at steady state, groundwater extraction either along or perpendicular to Huron Street will have little effect on the future distribution of dissolved constituents. Recognizing the limited withdrawal rates that can be achieved in the modeled area due to the low saturated thickness of the alluvium, the limited benefit achieved from these withdrawals, it is concluded that groundwater extraction cannot attain ARAR. This conclusion must be verified through a long term program of groundwater monitoring in the area of concern.

The modeling indicated that in all four scenarios and considering advection, the area of contamination will increase by about 50 percent in 30 years. The average concentration would have dropped from about 528 ppb to about 324 ppb due to dilution. The biodegradation analysis indicated that the time for all PCP to biodegrade ranges from 20 to 30 years. The analysis also included estimating the time to get to a concentration of 1 ppb north of the BWP Property through both advection and biodegradation. The analysis indicated that biodegradation is the main attenuation process for the contamination present north of the BWP Property and that attenuation through advection will only reduce the time by 3 percent. Analysis of the worst case scenario indicated that PCP concentrations of 1 ppb will be reached in approximately 60 years through biodegradation. While the results are promising, verification through long term monitoring must be implemented.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SCALE 1"=600'
CLEAR CREEK
GORDON LAKE
FLOW DIRECTION
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5190
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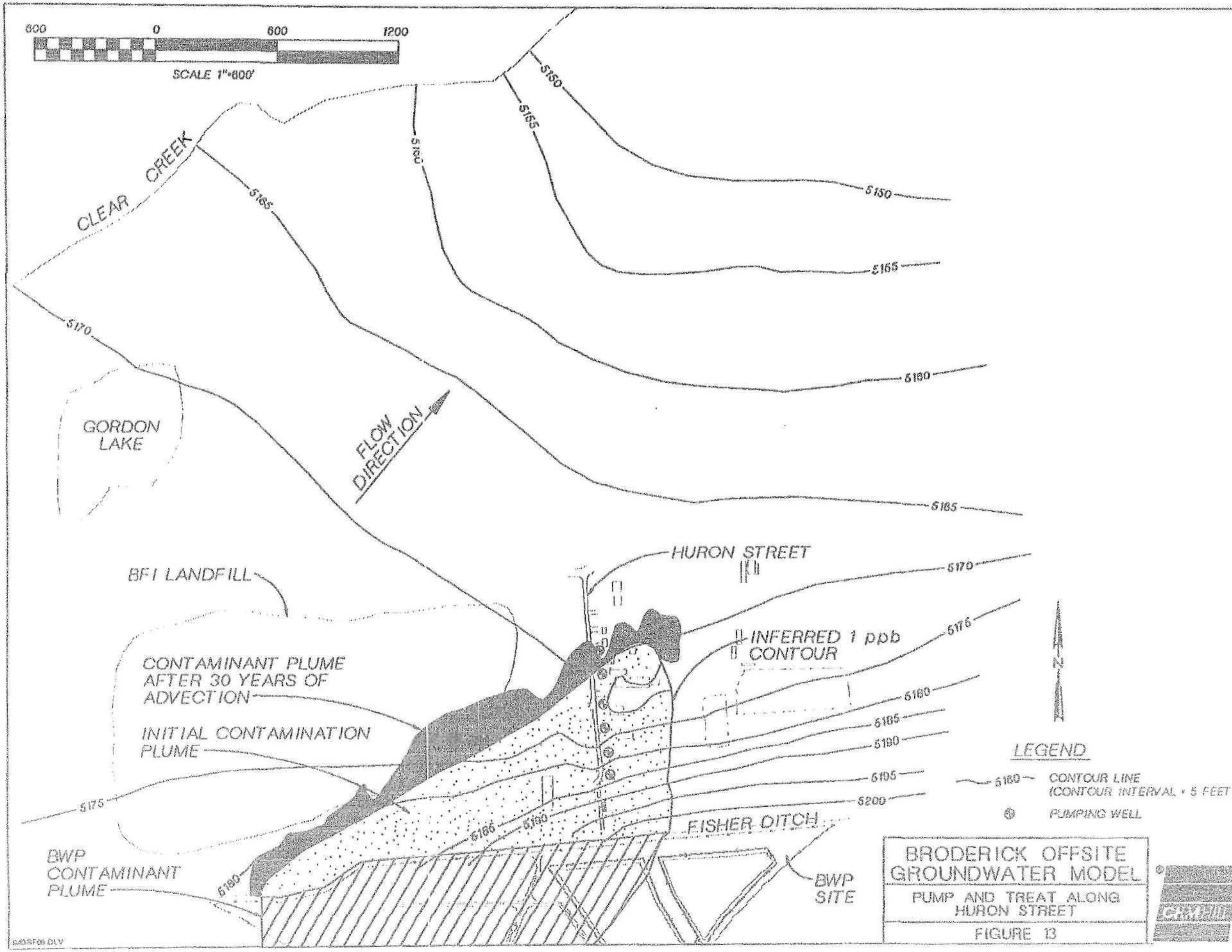
BFI LANDFILL
HURON STREET
INFERRED 1 ppb CONTOUR
CONTAMINANT PLUME AFTER 30 YEARS OF ADVECTION
INITIAL CONTAMINATION PLUME
BWP CONTAMINANT PLUME
FISHER DITCH
BWP SITE
N
LEGEND
5160 CONTOUR LINE (CONTOUR INTERVAL = 5 FEET)
BRODERICK OFFSITE GROUNDWATER MODEL
NATURAL ATTENUATION
FIGURE 12
CH2M HILL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CLEAR CREEK
GORDON LAKE
FLOW DIRECTION
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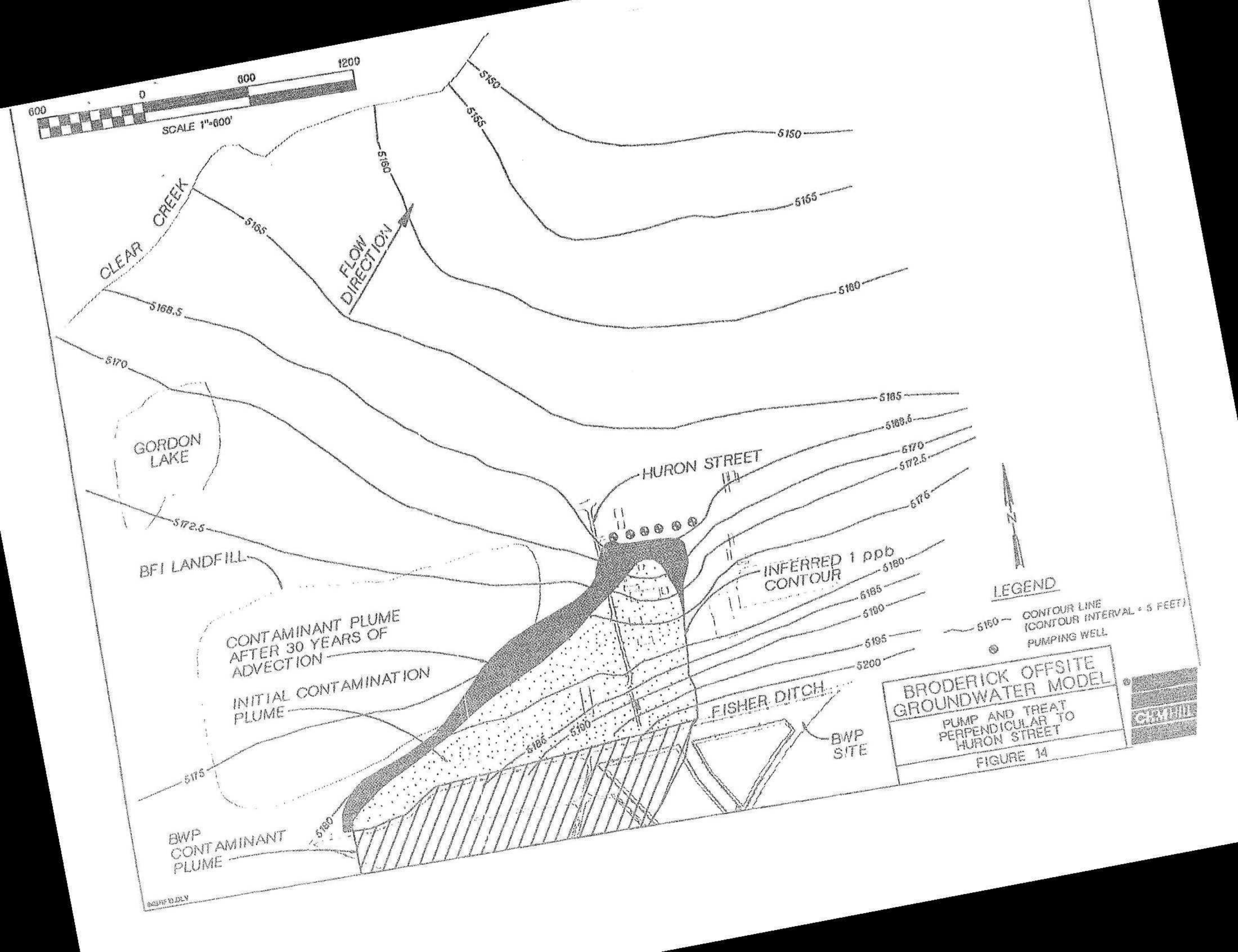
HURON STREET
BFI LANDFILL
INFERRED 1 ppb CONTOUR
CONTAMINANT PLUME AFTER 30 YEARS OF ADVECTION
INITIAL CONTAMINATION PLUME
FISHER DITCH
BWP CONTAMINANT PLUME
BWP SITE
N
LEGEND
CONTOUR LINE (CONTOUR INTERVAL = 5 FEET)
PUMPING WELL
BRODERICK OFFSITE GROUNDWATER MODEL
PUMP AND TREAT ALONG HURON STREET
FIGURE 13



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GORDON LAKE
HURON STREET
BFI LANDFILL
INFERRED 1 ppb CONTOUR
CONTAMINANT PLUME AFTER 30 YEARS OF ADVECTION
INITIAL CONTAMINATION PLUME
FISHER DITCH
BWP SITE
BWP CONTAMINANT PLUME
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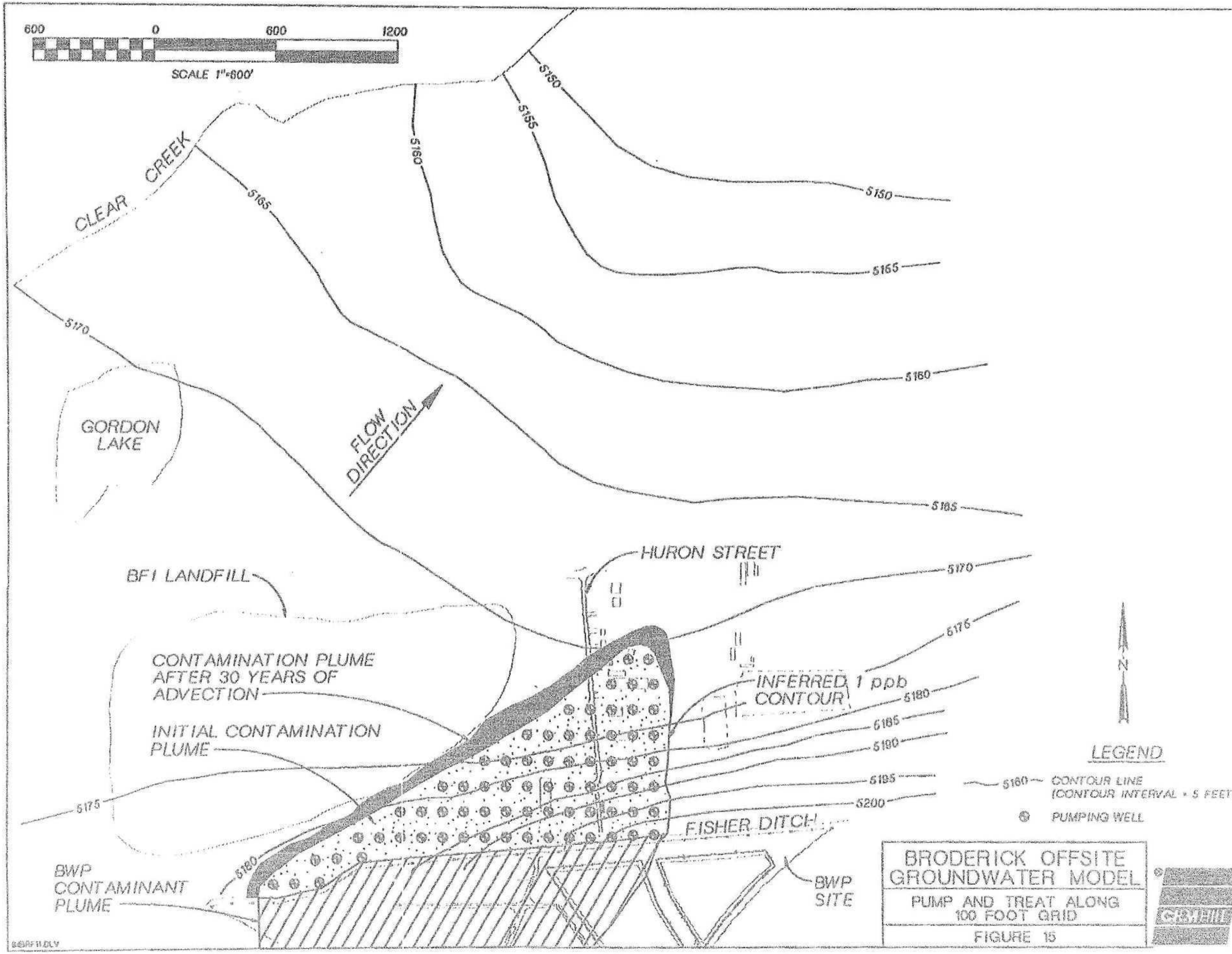
LEGEND
CONTOUR LINE (CONTOUR INTERVAL = 5 FEET)
PUMPING WELL
BRODERICK OFFSITE GROUNDWATER MODEL
PUMP AND TREAT PERPENDICULAR TO HURON STREET
FIGURE 14
CH2M HILL



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1200
SCALE 1"=600'
CLEAR CREEK
GORDON LAKE
FLOW DIRECTION
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HURON STREET
BFI LANDFILL
CONTAMINATION PLUME AFTER 30 YEARS OF ADVECTION
INITIAL CONTAMINATION PLUME
INFERRED 1 ppb CONTOUR
FISHER DITCH
BWP CONTAMINANT PLUME
BWP SITE
N
LEGEND
5160 CONTOUR LINE (CONTOUR INTERVAL = 5 FEET)
PUMPING WELL
BRODERICK OFFSITE GROUNDWATER MODEL
PUMP AND TREAT ALONG 100 FOOT GRID
FIGURE 15
CH2M HILL

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Appendix A
Comments Received
on the Proposed
Explanation of Significant Differences

BURLINGTON NORTHERN RAILROAD

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Burlington Northern Railroad
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October 12, 1994

Mr. Armando Saenz
Superfund Project Manager
U.S. Environmental Protection Agency
Region VIII
999 - 18th Street, Suite 500
Denver, CO 80202-2466

SUBJECT: Comments on Explanation of Significant Differences
Ground-Water Remedy
Dated September 15, 1994
Broderick Wood Products Site

Dear Mr. Saenz:

INTRODUCTION

The purpose of this letter is to provide comments by Burlington Northern Railroad (BN) and its consultants on the technical aspects of the Explanation of Significant Differences (ESD) for the ground-water remedy for the Broderick Wood Products Site. BN appreciates the opportunity to be able to submit comments and respectively requests that EPA consider these comments. BN requests that these comments be inserted in the Administrative Record.

BN's overall comment on EPA's changes to the ground-water remedy, which was set forth in the Record of Decision (ROD) for OU2 (EPA, 1992), is that the current changes should have been more strongly considered as part of the ROD in 1992 as most of the new data collected by EPA since the ROD does change the conceptual model of the site. In general, BN concurs with the State of Colorado and agrees with many of the proposed EPA changes, however, BN feels obligated to point out many of the mistakes and misleading statements in EPA's Explanation of Significant Differences. EPA states several reasons why significant differences now exist from the ground-water remedy described in the ROD. The principle reason seems to be the "new" information gained through additional characterization activities and treatability studies at the site. Contrary to EPA's reasons for the significant differences, BN is of the opinion that very little of the "new" data collected during additional studies over the past two years has actually raised the level of understanding of the hydrogeology, chemical distribution, or treatment technologies at the site.

Since issuance of the ROD for OU2, BN has strongly objected to the selected remedy for on-site ground water citing several reasons. First, the site is in an industrial setting and will remain so for the foreseeable future, thus, cleanup of shallow ground water to drinking-water standards is not necessary. Furthermore, the shallow water-bearing zone has a very low transmissivity and is not even capable of supplying water to meet residential needs and even less so for industrial requirements. In addition, background water quality of the shallow water-bearing zone is also known to be poor. Together, the above reasons are the basis for BN's opinion that remediation of the shallow water-bearing zone to drinking water standards is not warranted, let alone technically possible in a reasonable amount of time. Any corresponding expenditure of funds is therefore wasteful.

For off-site ground water, BN has stated that it is highly likely that the background water quality of shallow ground water is poor due to landfill activities and other industrial activities in the area. Natural biodegradation and attenuation of ground water to the north of the site was recommended as a more appropriate remedy than the pump and treat remedy cited in the ROD for OU2. Natural attenuation and decay of PCP was modeled by BN's consultants, and it was shown to be an effective and appropriate remedy instead of pump and treat. BN's major comments can be aptly summarized in the following points. Each of these points will be elaborated upon in later sections of this document. The salient points are:

- The "new" data was not necessary to reach the conclusion that the remediation goals listed in the ROD for on-site shallow ground water could not be met.

- The "new" data was not necessary to reach the conclusion that biodegradation and natural attenuation of chemicals in the off-site ground water could probably reach the goals listed in the ROD.

- Given the fact that the EPA and its consultants failed to incorporate the data in the RI's in the design of the North Boundary Cut-Off System (NBC), now the EPA wants to install a costly soil/bentonite wall. If the NBC is effective in capturing the on-site ground water before it leaves the site, then there are more economical and technically sound alternatives to the wall that will reduce the amount of water entering the NBC from Fisher Ditch. One such alternative is to line the ditch, the estimated cost of lining the ditch is approximately $150,000 versus the $700,000 for the soil/bentonite wall.

- All of the goals for the remediation of the on-site ground water can be achieved with the existing NBC. The proposed additional drains and bioventing system are not necessary.

- The ESD makes reference to a single plume when there are two distinct plumes at this site. A Federal Court of law determined that there are two distinct plumes at the site. It is arbitrary and capricious for EPA to maintain that there is one plume, in light of its opportunity to fully litigate this issue before the Court and the fact that the EPA lost this argument.

The following presents BN's specific comments to EPA's Explanation of Significant Differences (ESD).

SPECIFIC COMMENTS

Page 4

The first footnote discusses the fact that the NBC is "designed to capture and contain contaminated surficial ground water on the BWP property." If this is the case, there does not appear to be a technically justifiable basis to build the soil/bentonite wall. Contaminants should not pass the NBC if it has been properly designed <u>and</u> installed.

Page 5

The term "residual NAPL" is highly subjective and it is BN's understanding that the determination of residual NAPL is based upon the observations of the field geologist. Such a determination is <u>highly</u> subjective and should not be used.

The last bullet at the top of the page lists the term "Dissolved - NAPL". This term appears to be contradictory; how can there be a dissolved non-aqueous phase liquid? If it is dissolved then it is aqueous, therefore, it is confusing to refer to NAPL as dissolved.

Page 7

The ESD states that an on-site water treatment plant has been constructed and that it will be used to treat water. The last paragraph on the page goes on to state that treatment <u>may</u> employ an activated clay and activated carbon treatment. At this stage of the project and in consideration of all of the money that has been spent, EPA <u>must</u> have a clear understanding of the treatment system.

Page 8

EPA states that the "number of monitoring wells on and off the site may be increased from 10 to 15 to between 25 and 30." Again the word "may" is used. EPA should be at a stage that "mays" are no longer needed. BN hopes that the use of these "mays" does not infer additional unnecessary studies are being proposed. The concept to increase the number of monitoring wells is wasteful and without technical basis. EPA must ask what information is needed to be obtained by monitoring? The answer is to monitor the migration of the off-site plume and to measure the decline of concentrations within the on-site and off-site plumes. The margins of the on-site plumes have been adequately defined and because the NBC is supposedly effective in capturing the on-site plumes (as stated in the ESD), then the only purpose of on-site monitoring is to measure concentration declines. This goal can be met by using three or four wells. The 1992 ROD states that 10 to 15 wells total for both on and off-site will be monitored. It is BN's technical opinion that the on-site and off-site plumes can be monitored with no more than 10 wells total. The wells should be monitored no more than twice a year during the first couple of years of monitoring and then yearly afterwards. More frequent monitoring is not necessary due to the low ground-water velocities.

Page 8

It is deceiving to the public for EPA to state that the basis for change is "new information." It is obvious that the EPA has paid for more data but there is relatively no "new" site information since the 1992 ROD.

Page 8

In the first bulleted item under the "Basis for Significant Changes" section there is a statement that "significant dumping of debris and wood preserving wastes appears to have occurred over much of the Site." The term "significant dumping" is a relative term and is often times misleading. Because it is a relative term and subjective, it should not be used in a technical document without further details or substantiation.

Page 8

The second bulleted item refers to one contaminant plume in the surficial aquifer. This statement is incorrect. A Federal Court determined that there are two separate and distinct plumes at the BWP site.

Page 9

EPA cites that the new information gained during additional studies at the site indicates that soils in the surficial aquifer are more heterogeneous than indicated in the Phase III studies. Furthermore, EPA states that the hydraulic conductivities of the surficial aquifer and weathered Denver Formation are relatively low.

The "new" geologic and hydrogeologic information is not significantly different than information known in 1992 when the ROD was drafted. Phase III studies show that the shallow water-bearing zone has a low hydraulic conductivity and past calculated hydraulic conductivities are similar to those estimated during the new additional studies. EPA's contractor knew or should have known that sediments in the shallow water-bearing zones can vary greatly. The heterogeneous nature of sediments was already known at the end of Phase III studies since this fact is evident in geologic logs of boreholes throughout the site. Consequently, the additional drilling of boreholes and testing of hydraulic conductivity since 1992 was not warranted. EPA's expenditure of funds in this area was therefore wasteful.

Page 9

BN agrees with the EPA that natural biodegradation will be as effective as a standard pump and treat program for the off-site plume.

Page 10

EPA states that the likelihood of exposure to ground-water contamination on the site is low because the site is in an industrialized area and institutional controls that restrict access can be implemented. This statement follows closely to what BN has advised EPA ever since BN's involvement in 1992. If the potential for exposure to ground water is minimal at the site and use of ground water can be restricted through the use of institutional controls, then how could EPA continue to insist that active on-site remediation is necessary?

Page 11

On page 11 of the ESD, EPA lists three modified goals for the contaminated ground water within the points of compliance. The second goal is a mass reduction goal; however, there is no statement as to how fast or how much the mass must be reduced.

The goal goes on to state that mass reduction will reduce migration of contaminated ground water beyond the points of compliance. This is a misleading statement given the fact that the

NBC is suppose to be effective in stopping the off-site migration of chemicals. The second goal on page 11 can be met as long as the NBC operates irrespective of what other action will take place on the site, such as, bioventing.

Page 12

EPA states that the treatability studies demonstrated that in-situ bioremediation, i.e., bio-venting, may produce a substantial reduction of contaminants in the surficial ground water. Based on BN's understanding of the results of the treatability studies, bio-venting may be effective, but the time required for remediation is uncertain. After several months of treatability studies, EPA's contractor still cannot determine whether or not a remediation technology will work and cannot give a reliable estimate for the total time necessary for cleanup. Results of treatability studies fail to add any confidence to the proposed bio-venting remedy. In addition, there is no indication in the ESD of how bio-venting will be accomplished. Specifically, is the site to be desaturated prior to implementation of the bio-venting? A more cost effective program may be to simply operate the NBC and treat that water.

Page 12

The first full paragraph on this page emphasizes the need for mass reduction on site and that bio-venting will accomplish this goal. What this section fails to mention is that there are alternatives to bio-venting for the on-site contamination.

Given the facts that the remediation goals listed in the 1992 ROD will not be achieved in a cost-effective or timely fashion, and that institutional controls will prevent access to the shallow ground water, the basic question is whether bio-venting is necessary? BN asserts that it is not and that any corresponding expenditure of funds in this area would be wasteful. The implementation of the bio-venting system was previously thought to require the dewatering of the site by the installation of an extensive drain system (although the drain system is not mentioned in the ESD).

After draining the site, the bio-venting system is proposed to be installed with, as stated in the ESD, uncertain results. The combination of the drainage system (which will require the treatment of the water) with bio-venting will be expensive (and largely unnecessary), especially given the fact that the results are uncertain. BN asserts that the objectives listed on page 11 can be met using only the NBC. While the mass removal rate may be less using the NBC, the objectives will still be met, even if the pumping is for a relatively long time. However, the ESD fails to provide any technical basis to establish that the bio-venting is more cost-effective. BN asserts that it is not.

Lastly, no new field studies are required to support BN's assertions. Instead, a simple evaluation of the existing data should lead EPA to the same conclusion as BN. EPA's basis for selecting bio-venting is therefore arbitrary and capricious.

Page 12

EPA states that the bio-venting system will operate until the reduction of contaminant concentrations levels off, as determined by EPA in consultation with the State. A more clear understanding of the anticipated contaminant-reduction levels should be provided by EPA, and the scientific basis for contaminant-reduction levels should also be clearly specified by EPA. Based on BN's understanding, the contaminant-reduction levels will not be based on health risks, or existing State or Federal standards, rather the levels will be based on a mutual agreement between EPA and the State. If this is the case, then the NCP requires and BN strongly recommends that the public and potentially responsible parties be allowed to comment on the assignment of contaminant-reduction levels.

Page 12

EPA states that the soil/bentonite cut-off wall will increase the efficiency of the NBC system; EPA, however, does not explain how the efficiency will be increased, as such BN disputes EPA's assertion. If the NBC was designed and operated properly, then it will prevent the migration of chemicals off of the property, thus the soil/bentonite wall is not necessary. As stated on page 4, note 1 of the EPA ESD document, the NBC is "designed to capture and contain contaminated surficial ground water on the BWP property." The only reason for the wall, from a chemical transport perspective, would be to provide prophylactic protection. This alternative is very expensive and is not proven to be necessary.

The only genuine technical reason to spend $700,000 on the wall is to minimize the seepage from Fisher Ditch to the NBC. In essence, the water from Fisher Ditch may cause an increase in water treatment costs, but the ESD fails to address this point.

What the ESD must do is explain whether it is more economical or more expensive to treat more water over the course of, say, 30 years, than to spend $700,000 today. The ESD must also look at other options to reduce the seepage. One option is to line Fisher Ditch that is adjacent to the site. BN estimates, under normal circumstances, that the ditch could be lined for approximately $150,000. Another option is to use a fixed-film bio-reactor, as stated in the ROD, to treat the larger volume of ground water if a soil/bentonite cut-off wall or a liner for Fisher Ditch are not used.

Page 13

A non-significant change cited by EPA is that a carbon treatment system for ground water will be used instead of a fixed film bioreactor as selected in the ROD. EPA states the basis for the change is the low ground-water flow rates and organic contaminant strengths found at the site. This information was available to EPA at the end of Phase III activities, at or about early 1992. Ground-water flow rates have always been expected to be low and contaminant strengths have not significantly changed since 1992. Although, EPA states that carbon treatment may be less costly, and it may, BN questions EPA's and their contractor's abilities to accurately and effectively evaluate remediation technologies.

If EPA pursues the folly of installing a drain system in conjunction with bioventing, the initial water flow rates may be relatively high, thus, carbon may not be the lowest cost or environmentally preferred treatment program. An evaluation of the cost-effectiveness of using carbon for the drainage of the site must be provided.

Page 14

Again, there is no discussion on this page as to how the dewatering system for the site will be integrated with the bio-venting and water treatment system. More importantly, because remedial goals will not be attained on-site, BN questions whether dewatering and bio-venting are needed. A more cost-effective approach would be to extract and treat water from the NBC.

Technical Memorandum (attached to the ESD report)
Final Preliminary Assessment of Offsite Contamination Migration September 8, 1994

Figure 1

As stated in the text, Figure 1 depicts the model domain and contaminant plume. However, the figure does not show the model domain or boundaries, instead it is left to the reader to infer where model boundaries are located. The figure does not show monitoring well BFI-12, which should be in the middle of the plume off-site. Has BFI-12 been abandoned or mistakenly omitted from the figure? BFI-12 has a long history of water quality measurements and omission of the water quality data may affect the average concentration of PCP in the off-site ground water.

Figure 1 does not clearly describe what contaminant(s) are contained in the off-site plume. Is the extent of the plume based on total contaminants or on PCP? A clearer description of the plume's composition is necessary. It is assumed that the contaminant plume is for PCP only.

The measured concentrations of contaminants presented in a table on Figure 1 exclude concentrations from BFI-12, which will affect the average concentration. As previously stated, it is not clear what compounds are represented in the table. The table also shows concentrations of contaminants for GP-1, GP-2, GP-9, and GP-12 to be 50 ppb, and the table does not state how these measurements were obtained. One can only speculate that measurement of ground-water concentrations from geoprobes were taken using an on-site instrument that is not capable of precise measurements. The measurements used to determine the average concentrations of off-site ground water are suspect and are not be representative of actual concentrations.

BN is of the strong opinion that the construction of Figure 1 is highly subjective and is misleading. The averaging process used by CH_2M-Hill is biased and not technically justifiable. If the analysis for PCP in well BFI-9 is deleted from the average, as is suggested by CH_2M-Hill, and zero or 1/2 of the detection limit is used instead of the detection limit for the non-detects (a technically justifiable approach), then the average PCP concentration is 12 to 25 ppb not the 528 ppb stated in the table on Figure 1.

To reiterate, EPA's depiction that there is one on-site plume of PCP was the issue of a recent legal action. The Federal Court in this action ruled that there are two separate and distinct sources of contamination on the property, and that there are two plumes.

Page 4

Several simplifying assumptions for the modeling effort are stated. One of the stated assumptions is that the aquifers at the site are homogeneous. This is contrary to the conclusion on page 9 of the technical memorandum (TM), which states that as a result of additional studies the soils are more heterogeneous that originally estimated. If data are available that would better represent the heterogeneities of the shallow water-bearing zone, then the data should have been incorporated into the model.

Figure 2

Figure 2 shows the hydraulic conductivity used for the alluvial terrace deposits, weathered Denver Formation, and flood plain deposits. The hydraulic conductivity for the alluvial terrace deposits is five feet/day, yet EPA's contractor claims that calculations during recent additional studies indicate that the hydraulic conductivity is much lower than originally estimated. BN's consultants estimated an average hydraulic conductivity for the alluvium to be seven feet/day. BN's consultant's estimate was based on information from Phase III investigations and the estimated hydraulic conductivity was used in a one-dimensional modeling effort to estimate cleanup concentrations for the shallow ground water. Furthermore, ReTeC used a similar value of hydraulic conductivity in their ground-water modeling of the process area. If hydraulic conductivities are reported to be much lower as a result of additional studies, then why is it that EPA's contractor opted to use a hydraulic conductivity (five feet/day) that is very similar to the average hydraulic conductivity estimated in 1992, at the end of Phase III investigations?

Page 11

Initial parameters for hydraulic conductivities are reported to have been set based on field data and data in the literature, and subsequently adjusted during calibration of the model. The procedure of parameter adjustment is widely practiced and an acceptable methodology; however, final values of parameters, in particular hydraulic conductivity, are not mentioned in the TM. Final values of all parameters used in a model should be documented in order for others to properly evaluate the calibration.

Page 13

The calibrated recharge is reported to be 2.2 inches per year. The calibrated recharge is higher than originally anticipated by EPA's contractor. A general rule of thumb of 10 percent of precipitation as recharge (1.4 inches for Denver) is then cited, and the calibrated recharge is stated as being similar to the "rule of thumb."

The calibrated recharge of 2.2 inches per year is probably an order of magnitude greater than actual recharge for the Denver area. The "rule of thumb" mentioned by EPA is more appropriate for wetter climates and is not applicable for the arid western states. In fact, many areas along the front range in Colorado are at net deficits between recharge and evapotranspiration. If such a high recharge is necessary to achieve a good fit between measured and modeled water levels, then other parameters or boundary conditions in the model are likely to be in error because if a reasonable recharge were used then the model would be out of calibration.

Page 13

The residual mean square error (RMS) is reported to be 4.5 feet. RMS is an unbiased measure of the discrepancy between measured and modeled water levels. A RMS of 4.5 for a model domain that is less than one square mile, while calibrating to only 23 water levels, is not acceptable and the model can be considered as not being properly calibrated.

Residuals are as great as 12 feet in the southwestern portion of the model near BFI-7 and CH-2. Furthermore, the predicted potentiometric head map (Figure 7) does not fit well with the measured water levels. The gradient immediately north of the site boundary is directed toward the north northwest, which is 90° different than the measured gradient which is toward the northeast.

Figure 7

As previously stated, the predicted head map does not accurately match with measured data. The probable reason for this is that the constant flux boundary assigned to Fisher Ditch is not correctly assigned in the model. The TM states that Fisher Ditch contributes water to the shallow ground water. Fisher Ditch is known to flow from west to east, but in viewing the potentiometric contour lines along Fisher Ditch on Figure 7 and assuming that water from Fisher Ditch reaches the water table uniformly, the potentiometric lines indicate that flow in the ditch is in the opposite direction, from east to west.

Ground-water levels along Fisher Ditch in the southwest portion of the model are too low resulting in a ground-water flow direction that is directed toward the northwest instead of toward the northeast. A fundamental part of ground-water modeling is to represent the actual ground-water system, which clearly has not been done by EPA. Thus, results and predictions based on the modeling effort should be viewed with caution.

Page 15

Sensitivity simulations were performed on the model. Hydraulic conductivity and recharge values were set equal to half and twice the calibrated values. The TM states that the model is not sensitive to these parameters.

The statement that the model is not sensitive to changes in hydraulic conductivity and recharge is not accurate. For example, comparison of Figure 7 (calibrated) with Figure 9 (twice the hydraulic conductivity) reveals that water levels changed as much as eight to 10 feet in some areas. Therefore, one can conclude that the model is indeed sensitive to changes in hydraulic conductivity. The same comparison can be made for recharge.

Page 20

The TM describes a biodegradation analysis conducted for the area north of the site. The off-site concentration of PCP is set at 528 ppb. This value is too high and not representative of actual or anticipated concentrations. The high value is biased by a single measurement of 4,452 ppb at BFI-9. A reevaluation of average concentrations is needed.

Page 22

Predictive, ground-water withdrawal simulations were performed with the model. The TM mentions that ground water is "not developed" in the off-site model domain. What is meant by "not developed?" Does this mean that once water is pumped it is assumed to be treated and reinjected? If so, what are the pumping rates and where is the water reinjected? The TM seems to contradict itself because it states that withdrawal simulations were performed, but then later on states that ground water is not developed, i.e., no pumping wells. The explanation of model simulations needs to be more precise and clear.

Page 23

Table 1 needs more explanation, for example, where does the CF concentration of 327 ppb come from. In the footnote, CF is defined as the "final concentration after advective alternation." This statement makes no technical sense at all.

CLOSURE

BN appreciates the opportunity to provide comments on the ESD. Our comments again can be summarized as the following:

- The ESD could have been written without the "new" information because the "new" information fails to enhance the technical understanding of the site.
- BN concurs that the off-site plume can be remediated through natural biodegradation and attenuation.
- The need for the soil/bentonite wall has not been established by EPA.
- The ESD is inaccurate in its description of on-site plumes as determined by a Federal Court with jurisdiction over this site, there exists two separated and distinct plumes, not one.
- All of the goals for the remediation of the on-site ground water can be achieved with the existing NBC. The proposed additional drains and bioventing system are not needed. To implement such a system would be an arbitrary and capricious decision that would results in an unnecessary expenditure of funds.

If you have any questions or comments regarding this letter, please contact the undersigned.

Sincerely,

David C. Seep

David C. Seep
Manager Environmental Projects
Burlington Northern Railroad Company

cc: Austin Buckingham - Colorado Department of Public Health and Environment
Elizabeth Hill - Burlington Northern
Gary Parish - Popham, Haik, Schnobrich
Bob Sterrett - Hydrologic Consultants, Inc.

Responsiveness Summary to Comments Received on the Proposed Explanation of Significant Differences

This Responsiveness Summary for the Broderick Wood Products Superfund Site (the site) was prepared to document and respond to the issues raised in comments received on the Proposed Explanation of Significant Differences (ESD), dated September 15, 1994.

The purpose of the Proposed ESD was to explain the significant differences between the ground-water remedy the U.S. Environmental Protection Agency (EPA) chose in the Record of Decision (ROD), signed on March 24, 1992, and the remedy that EPA now proposes to implement for the ground water at the site. The EPA is the lead agency at the site; the State of Colorado Department of Public Health and Environment (CDPHE, formerly known as CDH) is the support agency.

This Proposed ESD provided a brief history of the site, described the original ground-water remedy selected in the ROD and explained the ways in which the proposed modified ground-water remedy differs from the original. It also summarized the support agency's comments on the proposed changes to the remedy, discussed the proposed modified remedy's compliance with all legal requirements, and provided details on how more information can be obtained or comments can be submitted on the proposed modified ground-water remedy.

The Proposed ESD was prepared in fulfillment of EPA's public participation responsibilities under Section 117(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601 et seq. (CERCLA or Superfund), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and Section 300.435(c)(2)(i) of the National Contingency Plan (NCP), 40 CFR Part 300.

EPA received public comments on the Proposed ESD for the ground-water remedy for a period of 30 days. The comment period extended from September 16, 1994 to October 15, 1994.

All comments were considered fully. These comments are included in the site Administrative Record. The only comments received were from Burlington Northern Railroad (BN) presented in a letter to the EPA dated October 12, 1994 (Appendix B). CDPHE concurs with this response to the comments.

This Responsiveness Summary contains EPA's response to the comments received. The format of the responses follows the format of BN's comments, and adjustments to the Proposed ESD were made in response to the comments.

RESPONSE TO GENERAL COMMENTS

The comments listed in this section are from both the Introduction and the Closure sections of BN's letter. Since both the comments and the corresponding responses are very similar, they are both listed in one location to simplify this responsiveness summary. For clarity, the comments are identified in the following text as to their location in the BN letter. The numbers associated with the comments did not come from the BN letter and are for clarity in this responsiveness summary.

1. **Comment:**

   - *"The "new" data was not necessary to reach the conclusion that the remediation goals listed in the ROD for on-site shallow ground water could not be met." (from the Introduction section)*

- *"The ESD could have been written without the "new" information because the "new" information fails to enhance the technical understanding of the site." (from the Closure section)*

Response:

EPA agrees that significant information on the site was available at the time the ROD was written. However, with the understanding of remediation technologies that was available in the remediation industry at the time the ROD was written, it was not possible to reach the conclusions that the remediation goals listed in the ROD for on-site shallow ground water could not be met. That conclusion can now be reached because of a better technical understanding of the site and the generally better understanding of remediation technologies and their limitations.

The most significant new information available since the ROD and its impact on the conclusions include:

- During construction of the Stage I Remedial Action (RA), considerable debris and waste were found at the location of the LTUs, surge pond, and north boundary cutoff (NBC) system. Because of the widespread debris and wood preserving waste, the sources of contamination are more extensive than previously thought, making remediation more difficult.

- The mobile light non-aqueous phase liquid (LNAPL) found in the impoundment area in the test wells installed as part of the design for Stage 2 RA covered a more extensive area than previously thought. This extent of the mobile LNAPL was first identified during the in-situ treatability studies and resulted in the addition of an active LNAPL recovery system into the Stage 2 design. The presence of LNAPL throughout the impoundment area will make it unlikely the ground-water based remediation goals in the ROD will be met on the Broderick Wood Products (BWP) property even after this mobile LNAPL is recovered.

- The hydraulic conductivity of the surficial aquifer is relatively low. EPA agrees that some information was available from the Remedial Investigation (RI) on the hydraulic conductivity. The emphasis of the Additional Studies was to fill in data gaps and provide further information on the certainty of the conclusions to be made, and only as necessary. Consequently, the ground-water investigations conducted as part of the Additional Studies were very limited. For example, only four new shallow ground-water wells were installed and three pumping tests/surge tests were performed on the surficial and weathered Denver formations. An evaluation of historical ground-water data at the site indicates that data collection has been inconsistent with respect to which wells were monitored, the time of year they were monitored, and the substances that were analyzed. Because of this, a complete ground-water sampling round was also performed. The data collected confirmed and reinforced the relatively low hydraulic conductivities measured previously. The low hydraulic conductivity suggests that cycling oxygenated water, as suggested in the Feasibility Study (FS), would not be effective in achieving the ground water based remediation goals in a reasonable period of time.

- Of the ground-water technologies available, it appears that none would be capable of reaching the remediation levels on the BWP property set out in Table 13 of the ROD within a reasonable period of time. This conclusion is based on information now readily available in the literature on remediation, and is based on performance of remediation systems at other sites.

2. **Comment:**

- *"The 'new' data was not necessary to reach the conclusion that biodegradation and natural attenuation of chemicals in the off-site ground water could probably reach the goals listed in the ROD." (from the Introduction section)*

- *"BN concurs that the off-site plume can be remediated through natural biodegradation and attenuation." (from the Closure section)*

Response:

The scope of the Additional Studies for ground water off of the BWP property was limited to filling in data gaps and increasing the certainty of any conclusions reached. Only nine new shallow wells were installed, and 21 temporary monitoring points were installed on the BWP Property. A round of ground-water sampling was conducted because a complete round had not been performed prior to this. The additional information obtained related to the extent of the contaminant plume and the nature of the ground-water contamination within the plume. The conclusion about natural attenuation achieving the off of the BWP property ground-water criteria was based on the additional information learned about the extent of the plume, the new information in the literature on natural attenuation/biodegradation, and the computer modeling described in the Technical Memorandum (TM) attached to the Proposed ESD.

3. **Comment:**

- *"Given the fact that the EPA and its consultants failed to incorporate the data in the RI's in the design of the North Boundary Cut-Off System (NBC), now the EPA wants to install a costly soil/bentonite wall. If the NBC is effective in capturing the on-site ground water before it leaves the site, then* *there are more economical and technically sound alternatives to the wall that will reduce the amount of water entering the NBC from Fisher Ditch. One such alternative is to line the ditch, the estimated cost of lining the ditch is approximately $150,000 versus the $700,000 for the soil/bentonite wall." (from the Introduction section)*

- *"The need for the soil/bentonite wall has not been established by EPA." (from the Closure section)*

Response:

It is not clear which RI data are being referred to in the comment. The wall will provide additional protection in times of mechanical difficulties and routine maintenance shutdown with the NBC system. For example, the wall will help prevent migration during periods of prolonged power outages, which can occur. This is even more important since, on the BWP property, ground water will not be treated to achieve drinking water standards. In addition, the soil/bentonite wall will extend deeper into the upper weathered Denver formation than the NBC to further limit the northward flow of ground water. As discussed by BN, the wall will also reduce the amount of water that enters the NBC system from Fisher Ditch. The costs of the wall are currently estimated to be about $210,000, not the $700,000 stated by BN. Also, it is likely that lining Fisher Ditch will cost more than $150,000 since the ditch must flow with at least 8 cfs all year round. Costs for temporarily diverting the ditch and lining it could be as high as $500,000.

4. **Comment:**

- *"All of the goals for the remediation of the on-site ground water can be achieved with the existing NBC. The proposed additional drains and bioventing system are not necessary." (from the Introduction section)*

- *"All of the goals for the remediation of the on-site ground water can be achieved with the existing NBC. The proposed additional drains and bioventing system are not needed. To implement such a system would be an arbitrary and capricious decision that would result in an unnecessary expenditure of funds."* *(from the Closure section)*

Response:

One of the remediation goals listed in the Proposed ESD for the contaminated ground water within the points of compliance is to reduce the mass of contamination on the BWP property to reduce migration of contaminated ground water beyond the points of compliance both vertically and horizontally. The existing NBC system will not provide significant mass reduction over the life of the project, or significantly impact vertical migration. Consequently, other Ras must be used to achieve the desired mass reduction. Since a significant part of the mass (and the most mobile part) appears to be present as mobile LNAPL, it is prudent to remove this mass first. This action is consistent with EPA's guidance (EPA, 1994), which recommends recovering mobile phase when possible. This will be accomplished with the drain line system. Further mass reduction will also be obtained by performing bioventing after the mobile LNAPL is removed. Bioventing will be accomplished at a relatively small incremental cost.

In addition, as mentioned in the Proposed ESD, the State of Colorado has stated that mass reduction in the impoundment area is necessary for the remedy to comply with closure requirements under RCRA for the interim status surface impoundments. These closure requirements are ARARs for the site.

5. **Comment:**

- *"The ESD makes reference to a single plume when there are two distinct plumes at this site. A Federal Court of law determined that there are two* *distinct plumes at the site. It is arbitrary and capricious for EPA to maintain that there is one plume, in light of its opportunity to fully litigate this issue before the Court and the fact that the EPA lost this argument." (from the Introduction section)*

- *"The ESD is inaccurate in its description of on-site plumes as determined by a Federal Court with jurisdiction over this site, there exists two separate and distinct plumes, not one." (from the Closure section)*

Response:

The Federal Court decision was based only on information from the RI/FS work performed before 1992. New information, which was not available to the court, now shows that the two plumes have merged. This new information is not critical to the remedy changes presented in the Proposed ESD. Consequently, the statement in the Proposed ESD about one plume is based on new information and is not related to the Federal Court decision.

RESPONSE TO SPECIFIC COMMENTS

(Please note that the page numbers referenced in the comments are from the September 15, 1994 Proposed ESD)

1. **Comment:**

Page 4—The first footnote discusses the fact that the NBC is "designed to capture and contain contaminated surficial ground water on the BWP property." If this is the case, there does not appear to be a technically justifiable basis to build the soil/bentonite wall. Contaminants should not pass the NBC if it has been properly designed and installed.

Response:

See Response 3 under Summary Points. No change to the ESD is required.

2. **Comment:**

Page 5—The term "residual NAPL" is highly subjective and it is BN's understanding that the determination of residual NAPL is based upon the observations of the field geologist. Such a determination is highly subjective and should not be used.

The last bullet at the top of the page lists the term "Dissolved—NAPL." This term appears to be contradictory; how can there be a dissolved non-aqueous phase liquid? If it is dissolved then it is aqueous, therefore, it is confusing to refer to NAPL as dissolved.

Response:

EPA agrees that the term "residual NAPL" is based on field observations. Although field determinations can be subjective, they often provide invaluable insights into technical issues. EPA agrees that the phrase "Dissolved NAPL" may be confusing and will be corrected to read "Dissolved NAPL Constituents." The ESD will be changed.

3. **Comment:**

Page 7—The ESD states that an on-site water treatment plant has been constructed and that it will be used to treat water. The last paragraph on the page goes on to state that treatment may employ an activated clay and activated carbon treatment. At this stage of the project and in consideration of all of the *money that has been spent, EPA <u>must</u> have a clear understanding of the treatment system.*

Response:

The on-site water treatment plant uses both clay and activated carbon. The ESD will be changed. The term "may employ" will be changed to "employs."

4. **Comment:**

Page 8—EPA states that the "number of monitoring wells on and off the site <u>may</u> be increased from 10 to 15 to between 25 and 30." Again the word "may" is used. EPA should be at a stage that "mays" are no longer needed. BN hopes that the use of these "mays" does not infer additional unnecessary studies are being proposed. The concept to increase the number of monitoring wells is wasteful and without technical basis. EPA must ask what information is needed to be obtained by monitoring? The answer is to monitor the migration of the off-site plume and to measure the decline of concentrations within the on-site and off-site plumes. The margins of the on-site plumes have been adequately defined and because the NBC is supposedly effective in capturing the on-site plumes (as stated in the ESD), then the only purpose of on-site monitoring is to measure concentration declines. This goal can be met by using three or four wells. The 1992 ROD states that 10 to 15 wells total for both on and off-site will be monitored. It is BN's technical opinion that the on-site and off-site plumes can be monitored with no more than 10 wells total. The wells should be monitored no more than twice a year during the first couple of years of monitoring and then yearly afterwards. More frequent monitoring is not necessary due to the low ground-water velocities.

Response:

EPA agrees that the word "may" is inappropriately used. The word "may" will be replaced with the word "will."

In the Proposed ESD, the concept of a vertical and horizontal point-of-compliance (POC) was proposed. The purpose of the POC is to describe a box beyond which contamination emanating from the site may not occur; and if it does, would indicate a failure of the remedy. The ground-water remedy combines (1) containment of continued off-property contaminant migration in the surficial aquifer by utilizing a barrier system at the north boundary, (2) on-property bioremediation to reduce contaminant mass and vertical migration, and (3) natural attenuation off-property to reduce contaminant concentrations to ground-water standards. Because the remedy has multiple components, each ground-water well in the network serves the function of monitoring the performance of that component.

The surficial aquifer and the Denver aquifer beneath the BWP property are contained within the POC. All aquifers vertically below the Denver aquifer on the property and horizontally outside of the property are subject to stricter standards. Due to the complexity of the Denver aquifer and the importance of the Arapahoe aquifer, there is the recognition that these aquifers require early detection and comprehensive monitoring. Early detection monitoring is used to provide the most efficient means of determining potential remedy failure. As a result, a series of ground-water monitoring wells are placed at the POC boundaries for both the Denver and Arapahoe aquifers. This monitoring well network provides early detection for protection of human health and the environment.

With natural attenuation selected as the off-property remedy, it is essential to monitor the remedy's performance within the plume area and to assess that natural attenuation is achieving the remedial goals. It is important to know the horizontal extent of the plume; therefore, continued migration of the plume must be monitored to ensure that additional impacts are not occurring.

Monitoring wells will be used to monitor the performance of the North Boundary Cutoff/Bentonite Wall system and to assure that a short-circuiting of the barrier system is not occurring. As the bioventing remedy is operated, monitoring wells will be used to track the remedy progress. This is standard operating procedure.

An evaluation of historical ground-water data at the site reveals that data collection has been inconsistent with respect to which wells were monitored, the time of year they were monitored, and the substances that were analyzed. This inconsistency in data collection does not lend itself to statistical analysis to determine monitoring frequency and well placement. Therefore, for the first two years, the ground-water wells will be monitored quarterly. These data will be used to develop a baseline data base against which all future data will be compared and appropriate monitoring frequencies can be determined.

Aside from the language change in the first paragraph of this response, no other changes to the ESD are required.

5. **Comment:**

Page 8—It is deceiving to the public for EPA to state that the basis for change is "new information." It is obvious that the EPA has paid for more data but there is relatively no "new" site information since the 1992 ROD.

Response:

See Response 1 under Summary Points. No change to the ESD is required.

6. **Comment:**

Page 8—In the first bulleted item under the "Basis for Significant Changes" section there is a statement that "significant dumping of debris and wood preserving wastes appears to have occurred over much of the site." The term "significant dumping" is a relative term and is often times misleading. Because it is a relative term and subjective, it should not be used in a technical document without further details or substantiation.

Response:

Roughly 18,000 cubic yards of debris and other waste, including wood preserving waste, were found over much of the site during construction of the OU 2, Stage 1 remedy. No change to the ESD is required.

7. **Comment:**

Page 8—The second bulleted item refers to one contaminant plume in the surficial aquifer. This statement is incorrect. A Federal Court determined that there are two separate and distinct plumes at the BWP site.

Response:

See Response 5 under Summary Points. No change to the ESD is required.

8. **Comment:**

Page 9—EPA cites that the new information gained during additional studies at the site indicates that soils in the surficial aquifer are more heterogeneous than indicated in the Phase III studies. Furthermore, EPA states that the hydraulic *conductivities of the surficial aquifer and weathered Denver Formation are relatively low.*

The "new" geologic and hydrogeologic information is not significantly different than information known in 1992 when the ROD was drafted. Phase III studies show that the shallow water-bearing zone has a low hydraulic conductivity and past calculated hydraulic conductivities are similar to those estimated during the new additional studies. EPA's contractor knew or should have known that sediments in the shallow water-bearing zones can vary greatly. The heterogeneous nature of sediments was already known at the end of Phase III studies since this fact is evident in geologic logs of boreholes throughout the site. Consequently, the additional drilling of boreholes and testing of hydraulic conductivity since 1992 was not warranted. EPA's expenditure of funds in this area was therefore wasteful.

Response:

See Response 1 under Summary Points. No change to the ESD is required.

9. **Comment:**

Page 9—BN agrees with the EPA that natural biodegradation will be as effective as a standard pump and treat program for the off-site plume.

Response:

Comment noted.

10. **Comment:**

Page 10—EPA states that the likelihood of exposure to ground-water contamination on the site is low because the site is in an industrialized area and institutional controls that restrict access can be implemented. This statement follows closely to what BN has advised EPA ever since BN's involvement in 1992. If the potential for exposure to ground water is minimal at the site and use of ground water can be restricted through the use of institutional controls, then how could EPA continue to insist that active on-site remediation is necessary?

Response:

See Response 4 under Summary Points. No change to the ESD is required.

11. **Comment:**

Page 11—On page 11 of the Proposed ESD, EPA lists three modified goals for the contaminated ground water within the points of compliance. The second goal is a mass reduction goal; however, there is no statement as to how fast or how much the mass must be reduced.

The goal goes on to state that mass reduction will reduce migration of contaminated ground water beyond the points of compliance. This is a misleading statement given the fact that the NBC is supposed to be effective in stopping the off-site migration of chemicals. The second goal on page 11 can be met as long as the NBC operates irrespective of what other action will take place on the site, such as, bioventing.

Response:

A specific amount of mass reduction to be achieved was not specified in the Proposed ESD. Rather, technologies have been selected (LNAPL recovery and bioventing) that have the greatest likelihood of achieving a large amount of mass reduction at a reasonable cost, and they will be operated to achieve the most mass reduction practical. Criteria for the duration of operation of the remediation technologies are being developed as part of the design and will be specified in operations plans.

It is believed that constructing and operating the selected technologies to achieve the most mass reduction that is practical will reduce migration of contaminated ground water beyond the points of compliance. EPA agrees that the NBC system and the soil bentonite cutoff wall will significantly reduce migration horizontally. However, they cannot be counted on as being totally fail safe for stopping horizontal migration, and they have no impact on vertical migration. Vertical migration is a significant concern since the Arapahoe aquifer is a major source of drinking water and it would be very difficult to vertically contain the site. Reducing the mass of contamination using NAPL recovery and bioventing will reduce the potential for contaminant migration since the mobile NAPL will be removed through the NAPL recovery system and bioventing will remove the most biodegradable contaminants, which are very often the most water-soluble. Use of the technologies will increase the overall protectiveness of the remedy by increasing the long-term effectiveness and permanence of the remedy and reducing the toxicity, mobility, and volume of contaminants in the surficial aquifer.

In addition, as mentioned in the Proposed ESD, the State of Colorado has stated that mass reduction in the impoundment area is necessary for the remedy to comply with closure requirements under RCRA for the interim status surface impoundments. These closure requirements are ARARs for the site. No change to the ESD is required.

12. **Comment:**

Page 12—EPA states that the treatability studies demonstrated that in-situ bioremediation, i.e., bio-venting, may produce a substantial reduction of contaminants in the surficial ground water. Based on BN's understanding of the results of the treatability studies, bio-venting may be effective, but the time required for remediation is uncertain. After several months of treatability studies, EPA's contractor still cannot determine whether or not a remediation technology will work and cannot give a reliable estimate for the total time necessary for cleanup. Results of treatability studies fail to add any confidence to the proposed bio-venting remedy. In addition, there is no indication in the ESD of how bio-venting will be accomplished. Specifically, is the site to be desaturated prior to implementation of the bio-venting? A more cost effective program may be to simply operate the NBC and treat that water.

Response:

The treatability studies did provide confidence that bioventing will "work." Significant microbial activity, which could be attributable to contaminant biodegradation, was observed during the studies. EPA agrees that the treatability studies only provided limited information on the total time necessary for bioventing operation. The treatability studies for the in-situ technologies were conducted over approximately a 1 month period. During that time, a number of technologies were evaluated. The objective of the in-situ treatability studies was to provide preliminary information of the effectiveness of the technologies. It will only be possible to determine the total time necessary for cleanup through long-term operation.

The details of the bioventing system are being prepared as part of the design for the OU 2, Stage 2 remedy. It is currently planned to dewater the site prior to implementation of the bioventing. Dewatering will be accomplished using the same drain lines to be used for LNAPL recovery, so there will be little additional cost for dewatering. In addition, the incremental amount of water to be treated from dewatering is expected to be small, once the system is initially dewatered. No change to the ESD is required.

13. **Comment:**

Page 12 – The first full paragraph on this page emphasizes the need for mass reduction on site and that bio-venting will accomplish this goal. What this section fails to mention is that there are alternatives to bio-venting for the on-site contamination.

Given the facts that the remediation goals listed in the 1992 ROD will not be achieved in a cost-effective or timely fashion, and that institutional controls will prevent access to the shallow ground water, the basic question is whether bio-venting is necessary? BN asserts that it is not and that any corresponding expenditure of funds in this area would be wasteful. The implementation of the bio-venting system was previously thought to require the dewatering of the site by the installation of an extensive drain system (although the drain system is not mentioned in the ESD).

After draining the site, the bio-venting system is proposed to be installed with, as stated in the ESD, uncertain results. The combination of the drainage system (which will require the treatment of the water) with bio-venting will be expensive (and largely unnecessary), especially given the fact that the results are uncertain. BN asserts that the objectives listed on page 11 can be met using only the NBC. While the mass removal rate may be less using the NBC, the objectives will still be met, even if the pumping is for a relatively long time. However, the ESD fails to provide any technical basis to establish that the bio-venting is more cost-effective. BN asserts that it is not.

Lastly, no new field studies are required to support BN's assertions. Instead, a simple evaluation of the existing data should lead EPA to the same conclusion as BN. EPA's basis for selecting bio-venting is therefore arbitrary and capricious.

Response:

The need to perform LNAPL recovery and bioventing have been discussed in Response 4 under the Summary Points, and Responses 11, and 12 under the Specific Comments. No change to the ESD is required.

14. **Comment:**

Page 12—EPA states that the bio-venting system will operate until the reduction of contaminant concentrations level off, as determined by EPA in consultation with the State. A more clear understanding of the anticipated contaminant-reduction levels should be provided by EPA, and the scientific basis for contaminant-reduction levels should also be clearly specified by EPA. Based on BN's understanding, the contaminant-reduction levels will not be based on health risks, or existing State or Federal standards, rather the levels will be based on a mutual agreement between EPA and the State. If this is the case, then the NCP requires and BN strongly recommends that the public and potentially responsible parties be allowed to comment on the assignment of contaminant-reduction levels.

Response:

A more clear understanding of the anticipated contaminant reduction levels cannot be provided at this time. As with the total time for bioventing to be completed, the long-term contaminant reduction time can only be determined through long-term operation. Criteria for the duration of the operation of the remediation technologies are being developed to satisfy State RCRA requirements to reduce contaminant mass. The criteria will be specified in operations plans. No change to the ESD is required.

15. **Comment:**

Page 12—EPA states that the soil/bentonite cut-off wall will increase the efficiency of the NBC system, EPA, however, does not explain how the efficiency will be increased, as such BN disputes EPA's assertion. If the NBC was designed and operated properly, then it will prevent the migration of chemicals off of the property, thus the soil/bentonite wall is not necessary. As stated on page 4, note 1 of the EPA ESD document, the NBC is "designed to capture and contain contaminated surficial ground water on the BWP property." The only reason for the wall, from a chemical transport perspective, would be to provide prophylactic protection. This alternative is very expensive and is not proven to be necessary.

The only genuine technical reason to spend $700,000 on the wall is to minimize the seepage from Fisher Ditch to the NBC. In essence, the water from Fisher Ditch may cause an increase in water treatment costs, but the Proposed ESD fails to address this point.

What the ESD must do is explain whether it is more economical or more expensive to treat more water over the course of, say, 30 years, than to spend $700,000 today. The ESD must also look at other options to reduce the seepage. One option is to line Fisher Ditch that is adjacent to the site. BN estimates, under normal circumstances, that the ditch could be lined for approximately $150,000. Another option is to use a fixed-film bio-reactor, as stated in the ROD, to treat the larger volume of ground water if a soil/bentonite cut-off wall or a liner for Fisher Ditch are not used.

Response:

See Response 3 under Summary Points. No change to the ESD is required.

16. **Comment:**

Page 13—A non-significant change cited by EPA is that a carbon treatment system for ground water will be used instead of a fixed film bioreactor as selected in the ROD. EPA states the basis for the change is the low ground-water flow rates and organic contaminant strengths found at the site. This information was available to EPA at the end of Phase III activities, at or about early 1992. Ground-water flow rates have always been expected to be low and contaminant strengths have not significantly changed since 1992. Although, EPA states that carbon treatment may be less costly, and it may, BN questions EPA's and their contractor's abilities to accurately and effectively evaluate remediation technologies.

If EPA pursues the folly of installing a drain system in conjunction with bioventing, the initial water flow rates may be relatively high, thus, carbon may not be the lowest cost or environmentally preferred treatment program. An evaluation of the cost-effectiveness of using carbon for the drainage of the site must be provided.

Response:

The use of activated carbon instead of biological treatment for the treatment of ground water during dewatering has been evaluated. Activated carbon combined with oleophilic clay was found to be cost-effective for low volumes of low concentration flow. If these conditions change, this conclusion will have to be re-evaluated. The ESD will not be changed at this time.

17. **Comment:**

Page 14—Again, there is no discussion on this page as to how the dewatering system for the site will be integrated with the bio-venting and water treatment system. More importantly, because remedial goals will not be attained on-site, BN questions whether dewatering and bio-venting are needed. A more cost-effective approach would be to extract and treat water from the NBC.

Response:

See Response 4 under Summary Points, and Response 12 under Specific Comments. No change to the ESD is required.

Technical Memorandum (attached to the ESD report)

Final Preliminary Assessment of Off-site Contamination Migration September 8, 1994

1. **Comment:**

Figure 1—As stated in the text, Figure 1 depicts the model domain and contaminant plume. However, the figure does not show the model domain or boundaries, instead it is left to the reader to infer where model boundaries are located. The figure does not show monitoring well BFI-12, which should be in the middle of the plume off-site. Has BFI-12 been abandoned or mistakenly omitted from the figure? BFI-12 has a long history of water quality measurements and omission of the water quality data may affect the average concentration of PCP in the off-site ground water.

Figure 1 does not clearly describe what contaminant(s) are contained in the off-site plume. Is the extent of the plume based on total contaminants or on PCP? A clearer description of the plume's composition is necessary. It is assumed that the contaminant plume is for PCP only.

The measured concentrations of contaminants presented in a table on Figure 1 exclude concentrations from BFI-12, which will affect the average concentration. As previously stated, it is not clear what compounds are represented in the table. The table also shows concentrations of contaminants for GP-1, GP-2, GP-9, and GP-12 to be 50 ppb, and the table does not state how these measurements were obtained. One can only speculate that measurement of ground-water concentrations from geoprobes were taken using an on-site instrument that is not capable of precise measurements. The measurements used to determine the average concentrations of off-site ground water are suspect and are not representative of actual concentrations.

BN is of the strong opinion that the construction of Figure 1 is highly subjective and is misleading. The averaging process used by CH2M HILL is biased and not technically justifiable. If the analysis for PCP in well BFI-9 is deleted from the average, as is suggested by CH2M HILL, and zero or 1/2 of the detection limit is used instead of the detection limit for the non-detects (a technically justifiable approach), then the average PCP concentration is 12 to 25 ppb not the 528 ppb stated in the table on Figure 1.

To reiterate, EPA's depiction that there is one on-site plume of PCP was the issue of a recent legal action. The Federal Court in this action ruled that there are two separate and distinct sources of contamination on the property, and that there are two plumes.

Response:

Figure 1 of the TM was modified to show the model domain boundary and location of monitoring well BFI-12.

The plume represented in Figure 1 is for PCP concentrations. The average concentration used in the analysis may be biased by concentrations from well BFI-9. EPA recognizes the bias but believes that it was not a problem because even with high concentrations, contaminant levels reached low values through bioattenuation within a reasonable time. The analysis was intended to be conservative and the outcome was the same whether BFI-9 results were used or not. Adding BFI-12 data will not change this conclusion; therefore, no change is required to the TM Attachment to the ESD.

2. **Comment:**

Page 4—Several simplifying assumptions for the modeling effort are stated. One of the stated assumptions is that the aquifers at the site are homogeneous. This is *contrary to the conclusion on page 9 of the technical memorandum (TM), which states that as a result of additional studies the soils are more heterogeneous that originally estimated. If data are available that would better represent the heterogeneities of the shallow water-bearing zone, then the data should have been incorporated into the model.*

Response:

The statement that the soils are more heterogeneous than originally estimated appears on page 9 of the Proposed ESD (not the TM). At the time of the modeling, little information on the degree of soil heterogeneity off of the BWP property was available, so EPA used simplifying assumptions in absence of data for the model.

The assumptions listed on page 4 of the TM were developed for the purpose of the model. As stated on page 4 of the TM, simplifying assumptions were made to reflect the uncertainties in the definition of the site characteristics.

One of the commonly applied assumptions in ground-water modeling is the assumption of uniform properties throughout an aquifer unit to reflect the overall "average" flow characteristics of a geologically heterogeneous unit. This is the approach that was taken for this site. Quantitative information regarding soil heterogeneities would not affect the outcome of the modeling assessment. No change is required to the TM attachment to the ESD.

3. **Comment:**

Figure 2—Figure 2 shows the hydraulic conductivity used for the alluvial terrace deposits, weathered Denver Formation, and flood plain deposits. The hydraulic conductivity for the alluvial terrace deposits is five feet/day, yet EPA's contractor claims that calculations during recent additional studies indicate that the hydraulic

conductivity is much lower than originally estimated. BN's consultants estimated an average hydraulic conductivity for the alluvium to be seven feet/day. BN's consultant's estimate was based on information from Phase III investigations and the estimated hydraulic conductivity was used in a one-dimensional modeling effort to estimate cleanup concentrations for the shallow ground water. Furthermore, ReTeC used a similar value of hydraulic conductivity in their ground-water modeling of the process area. If hydraulic conductivities are reported to be much lower as a result of additional studies, then why is it that EPA's contractor opted to use a hydraulic conductivity (5 feet/day) that is very similar to the average hydraulic conductivity estimated in 1992, at the end of Phase III investigations?

Response:

It is evident that there are uncertainties in the field parameters used in the modeling. The use of an average hydraulic conductivity of 5 feet/day was arrived at through field data and matching observed heads. No matter what value is used there will always be uncertainties. To address that, a sensitivity analysis was completed and is described on page 13 of the memo. No change is required to the TM attachment to the ESD.

4. **Comment:**

Page 11—Initial parameters for hydraulic conductivities are reported to have been set based on field data and data in the literature, and subsequently adjusted during calibration of the model. The procedure of parameter adjustment is widely practiced and an acceptable methodology; however, final values of parameters, in particular hydraulic conductivity, are not mentioned in the TM. Final values of all parameters used in a model should be documented in order for others to properly evaluate the calibration.

Response:

Table 1 of this responsiveness summary presents the final values for the parameters.

Table 1 Model Input Parameters	
Parameter	**Value**
Water Level	Figure 6
Top of Weathered Denver	Figure 3
Bottom of Weather Denver	Figure 4
Thickness of Weathered Denver	20 feet
Thickness of Alluvium	Values from Figure 6 minus values from Figure 3
Recharge Rate	1 inch
Hydraulic Conductivity of Flood Plain	100 ft/day
Hydraulic Conductivity of Alluvium	0.66 - 0.8 ft/day
Hydraulic Conductivity of Weathered Denver	10^{-2} ft/day
Final Hydraulic Conductivity for Weathered Denver	10^{-1} ft/day

5. **Comment:**

Page 13—The calibrated recharge is reported to be 2.2 inches per year. The calibrated recharge is higher than originally anticipated by EPA's contractor. A general rule of thumb of 10 percent of precipitation as recharge (1.4 inches for Denver) is then cited, and the calibrated recharge is stated as being similar to the "rule of thumb."

The calibrated recharge of 2.2 inches per year is probably an order of magnitude greater than actual recharge for the Denver area. The "rule of thumb" mentioned by EPA is more appropriate for wetter climates and is not applicable for the arid western states. In fact, many areas along the front range in Colorado are at net deficits between recharge and evapotranspiration. If such a high recharge is necessary to achieve a good fit between measured and modeled water levels, then other parameters or boundary conditions in the model are likely to be in error because if a reasonable recharge were used then the model would be out of calibration.

Response:

As stated on Page 13 of the TM, the high recharge may be attributed to the nature of the floodplain and seepage from Fisher Ditch to the vadose zone. Therefore, the recharge value needed to achieve model calibration is not entirely contributed by precipitation but is rather a combination of flat topography, seepage from Fisher Ditch, and precipitation. No change is required to the TM attachment to the ESD.

6. **Comment:**

Page 13—The residual mean square error (RMS) is reported to be 4.5 feet. RMS is an unbiased measure of the discrepancy between measured and modeled water levels. A RMS of 4.5 for a model domain that is less than one square mile, while calibrating to only 23 water levels, is not acceptable and the model can be considered as not being properly calibrated.

Residuals are as great as 12 feet in the southwestern portion of the model near BFI-7 and CH-2. Furthermore, the predicted potentiometric head map (Figure 7) does not fit well with the measured water levels. The gradient immediately north *of the site boundary is directed toward the north northwest, which is 90° different than the measured gradient which is toward the northeast.*

Response:

The calibration results were felt to be adequate for the purposes of the modeling effort, particularly in light of the fact that the model was used for particle tracking, in order to access the flow path of potential contaminants leaving the site. As a result, similarity in ground-water gradients and flow trajectories is more critical than an exact match of measured and modeled heads.

The level of calibration depends on both the complexity of the model and the extent of the available data. A more rigorous calibration would have been inappropriate to the available data. As stated on page 13 of the TM, the following goals were used in the calibration of the model:

- The model should yield the same water level distribution configuration as the target water levels.

- The model should accurately depict the overall gradient within the model domain.

Matching the exact location of each contour was not considered an important calibration criteria because of the uncertainty in the data. The water level data were drawn from two separate sets of water levels.

The comment states that a (modeled) gradient immediately north of the site boundary is 90 degrees different from the measured gradient. Figure 6 of the TM shows the observed ground-water potentiometric surface at and north of the site. Figure 7 of the TM shows the predicted potentiometric surface. Close comparison of these figures demonstrates very good agreement between the observed and predicted shapes of the potentiometric surfaces, as well as overall flow directions. No change is required to the TM attachment to the ESD.

7. **Comment:**

Figure 7—As previously stated, the predicted head map does not accurately match with measured data. The probable reason for this is that the constant flux boundary assigned to Fisher Ditch is not correctly assigned in the model. The TM states that Fisher Ditch contributes water to the shallow ground water. Fisher Ditch is known to flow from west to east, but in viewing the potentiometric contour lines along Fisher Ditch on Figure 7 and assuming that water from Fisher Ditch reaches the water table uniformly, the potentiometric lines indicate that flow in the ditch is in the opposite direction, from east to west.

Ground-water levels along Fisher Ditch in the southwest portion of the model are too low resulting in a ground-water flow direction that is directed toward the northwest instead of toward the northeast. A fundamental part of ground-water modeling is to represent the actual ground-water system, which clearly has not been done by EPA. Thus, results and predictions based on the modeling effort should be viewed with caution.

Response:

The actual ground-water system has been represented properly. Although Fisher Ditch is contributing infiltration to the ground-water system, Fisher Ditch does not penetrate the ground-water system. The elevation of the water in Fisher Ditch is higher than the elevation of the ground water below the ditch. There is currently no available data along Fisher Ditch to add more resolution in that area. No change to the TM attachment to the ESD is required.

8. **Comment:**

Page 15—Sensitivity simulations were performed on the model. Hydraulic conductivity and recharge values were set equal to half and twice the calibrated values. The TM states that the model is not sensitive to these parameters.

The statement that the model is not sensitive to changes in hydraulic conductivity and recharge is not accurate. For example, comparison of Figure 7 (calibrated) with Figure 9 (twice the hydraulic conductivity) reveals that water levels changed as much as eight to 10 feet in some areas. Therefore, one can conclude that the model is indeed sensitive to changes in hydraulic conductivity. The same comparison can be made for recharge.

Response:

Predicted heads may be affected by increasing or decreasing certain parameter values. However, as explained in response No. 7, since this is a particle tracking model, the specific value of the predicted is less critical than having the overall shape of the predicted water table match the overall shape of the observed water table. No change to the TM attachment to the ESD is required.

9. **Comment:**

Page 20—The TM describes a biodegradation analysis conducted for the area north of the site. The off-site concentration of PCP is set at 528 ppb. This value is too high and not representative of actual or anticipated concentrations. The high value is biased by a single measurement of 4,452 ppb at BFI-9. A re-evaluation of average concentrations is needed.

Response:

A reevaluation of average concentration is not needed as the biodegradation analysis conducted with the higher concentration indicated that MCLs, even with the higher concentration, are reached within a reasonable time. This indicates that even with a very conservative analysis, the basic conclusions drawn from the modeling effort do not change. No change to the TM attachment to the ESD is required.

10. Comment:

Page 22—Predictive, ground water withdrawal simulations were performed with the model. The TM mentions that ground water is "not developed" in the off-site model domain. What is meant by "not developed?" Does this mean that once water is pumped it is assumed to be treated and reinjected? If so, what are the pumping rates and where is the water reinjected? The TM seems to contradict itself because it states that withdrawal simulations were performed, but then later on states that ground water is not developed, i.e., no pumping wells. The explanation of model simulations needs to be more precise and clear.

Response:

As stated in the TM, the modeling assumes that ground water in the area is not developed for industrial, municipal, or domestic use. This means that there is no industrial, municipal, or domestic use of ground water. In other words, aside from remedial wells, there are no active pumping wells that may affect ground-water flow and contaminant transport. No change to the TM attachment to the ESD is required.

11. **Comment:**

Page 23—Table 1 needs more explanation, for example, where does the CF concentration of 327 ppb come from. In the footnote, CF is defined as the "final concentration after advective alternation." This statement makes no technical sense at all.

Response:

C_f is the final concentration after advective transport. This means that the same original mass is now distributed throughout a plume whose area is larger than the original plume. The footnote on Table 1 of the TM will be changed to read "final concentration after advective transport."

References

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